

PB84-120328

Emission Characterization of Major
Fossil Fuel Power Plants in the
Ohio River Valley

PEDCo-Environmental, Inc., Cincinnati, OH

Prepared for

Environmental Sciences Research Lab.
Research Triangle Park, NC

Nov 83

U.S. Department of Commerce
National Technical Information Service

NTIS

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)		
1. REPORT NO. EPA-600/3-83-109	2.	3. RECIPIENT'S ACCESSION NO. PB8 4 120328
4. TITLE AND SUBTITLE EMISSION CHARACTERIZATION OF MAJOR FOSSIL FUEL POWER PLANTS IN THE OHIO RIVER VALLEY		5. REPORT DATE November 1983
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Gary Baker, Paul Clarke, Richard Gerstle, Wade Mason, and Mark Phillips		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS PEDCo Environmental, Inc. 11499 Chester Road Cincinnati, Ohio 45246		10. PROGRAM ELEMENT NO. CDTAID-03 -0550 (FY-83)
		11. CONTRACT/GRANT NO. 68-02-3271
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Sciences Research Laboratory- RTP, NC Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, N.C. 27711		13. TYPE OF REPORT AND PERIOD COVERED Final
		14. SPONSORING AGENCY CODE EPA/600/09
15. SUPPLEMENTARY NOTES		
16. ABSTRACT This study characterizes the atmospheric emissions from five major coal-fired power plant units in the Ohio River Valley between Portsmouth, Ohio, and Louisville, Kentucky. This characterization provides data that are representative of the boiler fuel emission control combinations of the current power plant population as well as those scheduled to go on line before the end of 1983. The Environmental Protection Agency will use this data to determine the impact of existing and planned power plants on air quality in this river valley.		
17. KEY WORDS AND DOCUMENT ANALYSIS		
a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC		19. SECURITY CLASS (This Report) UNCLASSIFIED
		20. SECURITY CLASS (This page) UNCLASSIFIED
		21. NO. OF PAGES 258
		22. PRICE

PB84-120328

EPA-600/3-83-109
November 1983

EMISSION CHARACTERIZATION OF MAJOR FOSSIL FUEL
POWER PLANTS IN THE OHIO RIVER VALLEY

by

Gary Baker, Paul Clarke, Richard Gerstle,
Wade Mason, and Mark Phillips
PEDCo Environmental, Inc.
Cincinnati, Ohio 45246

Contract No. 68-02-3271

Project Officer

Kenneth T. Knapp
Emissions Measurement and Characterization Division
Environmental Sciences Research Laboratory
Research Triangle Park, N.C. 27711

ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, N.C. 27711

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

This study characterizes the atmospheric emissions from five major coal-fired power plant units in the Ohio River Valley between Portsmouth, Ohio, and Louisville, Kentucky. This characterization provides data that are representative of the boiler fuel emission control combinations of the current power plant population as well as those scheduled to go on line before the end of 1983. The Environmental Protection Agency will use these data to determine the impact of existing and planned power plants on air quality in this river valley.

CONTENTS

Abstract	iii
Figures	vi
Tables	xi
1. Introduction	1-1
2. Site Selection and Process Descriptions	2-1
Geographical Limits of Study	2-1
Boiler Criteria	2-3
3. Sampling Methods and Locations	3-1
4. Summary of Results	4-1
Particulate Emissions	4-1
Particle Size Distribution	4-9
Trace Element Analysis	4-19
Sulfur Emissions	4-63
Sulfur Dioxide	4-63
Sulfuric Acid Mist	4-68
Particulate Sulfate	4-70
Gaseous NO ₂ and NO _x Emissions	4-73
Particulate and Gaseous Chloride Emissions	4-78
Particulate and Gaseous Fluorides	4-84
5. Pollutant Mass Emission Rates for Plants Presently Operating in the Study Region	5-1
Filterable Particulate Emissions	5-1
Sulfur Emissions	5-10
Sulfur Dioxide	5-10
Sulfuric Acid Mist	5-19
Particulate Sulfate Emissions	5-27
Gaseous NO ₂ and NO _x Emissions	5-35
Particulate and Gaseous Chloride Emission Rates	5-50
Particulate Fluoride and Gaseous HF	5-65
6. Projected Pollutant Mass Emission Rates from Plants Coming on Line by the End of 1983	6-1
Appendix B - Plant Operating Data	B-1
Appendix C - Sampling Locations	C-1
Appendix D - Sampling and Analytical Procedures	D-1

FIGURES

<u>Number</u>		<u>Page</u>
2-1	Coal-Fired Power Plants Located in the Study Area Along the Ohio River	2-2
2-2	Total Generating Capacity of the Study Region	2-8
3-1	Continuous Emission Monitoring System (CEMS)	3-5
4-1	Plant A Total Mass Mean Cumulative Curve	4-10
4-2	Plant B Total Mass Mean Cumulative Curve	4-11
4-3	Plant C Total Mass Mean Cumulative Curve	4-12
4-4	Plant D Total Mass Mean Cumulative Curve	4-13
4-5	Plant E Total Mass Mean Cumulative Curve	4-14
4-6	X-Ray Fluorescence Quality Control Data (XRF-3)	4-22
4-7	Plant A Elemental Concentration Size Distribution	4-30
4-8	Plant B Elemental Concentration Size Distribution	4-31
4-9	Plant C Elemental Concentration Size Distribution	4-32
4-10	Plant D Maximum Elemental Concentration Measured	4-34
4-11	Plant E Maximum Elemental Concentration Measured	4-35
4-12	Plant A Trace Element Concentrations for Particles Less Than 9.7 μm	4-36
4-13	Plant A Trace Element Concentrations for Particles Less Than 4.0 μm	4-37
4-14	Plant A Trace Element Concentrations for Particles Less Than 1.1 μm	4-38

FIGURES (continued)

<u>Number</u>		<u>Page</u>
4-15	Plant A Trace Element Concentrations for Particles Less Than 0.36 μm	4-39
4-16	Plant B Trace Element Concentrations for Particles Less Than 8.5 μm	4-40
4-17	Plant B Trace Element Concentrations for Particles Less Than 3.8 μm	4-41
4-18	Plant B Trace Element Concentrations for Particles Less Than 0.93 μm	4-42
4-19	Plant B Trace Element Concentrations for Particles Less Than 0.29 μm	4-43
4-20	Plant C Trace Element Concentrations for Particles Less Than 9.8 μm	4-44
4-21	Plant C Trace Element Concentrations for Particles Less Than 4.05 μm	4-45
4-22	Plant C Trace Element Concentrations for Particles Less Than 1.1 μm	4-46
4-23	Plant C Trace Element Concentrations for Particles Less Than 0.38 μm	4-47
4-24	Plant D Trace Element Concentrations for Particles Less Than 8.3 μm	4-48
4-25	Plant D Trace Element Concentrations for Particles Less Than 3.4 μm	4-49
4-26	Plant D Trace Element Concentrations for Particles Less Than 0.92 μm	4-50
4-27	Plant D Trace Element Concentrations for Particles Less Than 0.30 μm	4-51
4-28	Plant E Trace Element Concentrations for Particles Less Than 8.9 μm	4-52
4-29	Plant E Trace Element Concentrations for Particles Less Than 3.6 μm	4-53
4-30	Plant E Trace Element Concentrations for Particles Less Than 0.98 μm	4-54

FIGURES (continued)

<u>Number</u>		<u>Page</u>
4-31	Plant E Trace Element Concentrations for Particles Less Than 0.32 μm	4-55
5-1	Total Monthly Filterable Particulate Emissions	5-3
5-2	Group I - Monthly Filterable Particulate Mass Emissions	5-7
5-3	Group II - Monthly Filterable Particulate Mass Emissions	5-8
5-4	Group III - Monthly Filterable Particulate Mass Emissions	5-9
5-5	Total Monthly Sulfur Dioxide Mass Emissions	5-15
5-6	Group I Monthly Sulfur Dioxide Mass Emissions	5-16
5-7	Group II Monthly Sulfur Dioxide Mass Emissions	5-17
5-8	Group III Monthly Sulfur Dioxide Mass Emissions	5-18
5-9	Total Sulfuric Acid Mist Mass Emissions From Groups I, II, and III	5-20
5-10	Group I Monthly Sulfuric Acid Mist Mass Emissions	5-24
5-11	Group II Monthly Sulfuric Acid Mist Mass Emissions	5-25
5-12	Group III Monthly Sulfuric Acid Mist Mass Emissions	5-26
5-13	Total Sulfate Mass Emissions	5-28
5-14	Group I Monthly Sulfate Mass Emissions	5-29
5-15	Group II Monthly Sulfate Mass Emissions	5-30
5-16	Group III Monthly Sulfate Mass Emissions	5-31
5-17	Total Monthly NO_2 Mass Emissions	5-36
5-18	Total Monthly NO_x Mass Emissions	5-37

FIGURES (continued)

<u>Number</u>		<u>Page</u>
5-19	Group I Monthly NO ₂ Mass Emissions	5-44
5-20	Group I Monthly NO _x Mass Emissions	5-45
5-21	Group II Monthly NO ₂ Mass Emissions	5-46
5-22	Group II Monthly NO _x Mass Emissions	5-47
5-23	Group III Monthly NO ₂ Mass Emissions	5-48
5-24	Group III Monthly NO _x Mass Emissions	5-49
5-25	Total Monthly Particulate Chloride Mass Emissions	5-51
5-26	Total Monthly Gaseous HCl Mass Emissions	5-52
5-27	Group I Monthly Particulate Chloride Mass Emissions	5-59
5-28	Group II Monthly Particulate Chloride Mass Emissions	5-60
5-29	Group III Monthly Particulate Chloride Mass Emissions	5-61
5-30	Group I Monthly HCl Mass Emissions	5-62
5-31	Group II Monthly HCl Mass Emissions	5-63
5-32	Group III Monthly HCl Mass Emissions	5-64
5-33	Total Monthly Particulate Fluoride Mass Emissions	5-66
5-34	Total Monthly Gaseous HF Mass Emissions	5-67
5-35	Group I Monthly Particulate Fluoride Mass Emissions	5-74
5-36	Group II Monthly Particulate Fluoride Mass Emissions	5-75
5-37	Group III Monthly Particulate Fluoride Mass Emissions	5-76
5-38	Group I Monthly Gaseous HF Mass Emissions	5-77
5-39	Group II Monthly Gaseous HF Mass Emissions	5-78
5-40	Group III Monthly Gaseous HF Mass Emissions	5-79

FIGURES (continued)

<u>Number</u>		<u>Page</u>
6-1	Projected Particulate Mass Emission Rates for 1983	6-4
6-2	Projected Gaseous Mass Emission Rates for 1983	6-5

TABLES

<u>Number</u>		<u>Page</u>
2-1	Coal-Fired Power Plants in the Ohio River Study Region	2-4
2-2	Generating Capacity (MWe) of Power Plants at Different Geographical Locations Along the Ohio River	2-7
3-1	Sampling Methods and Number of Runs per Pollutant for Each Boiler	3-2
3-2	Continuous Monitors Used for each Gaseous Pollutant	3-6
4-1	Particulate Emission Factors	4-2
4-2	Gaseous Emission Factors	4-3
4-3	Group I - Total Filterable Particulate Emission Rates Determined From Method 5 Samples	4-4
4-4	Group II - Total Filterable Particulate Emission Rates Determined From Method 5 Samples	4-5
4-5	Group III - Total Filterable Particulate Emission Rates Determined From Method 5 Samples	4-6
4-6	Comparison of Particle Size Distribution Concentrations to Method 5 Concentrations	4-15
4-7	Percentage of Inhalable and Fine Particulate	4-18
4-8	NAA Quality Assurance Data	4-23
4-9	Quality Assurance Filter QA-1	4-24
4-10	Quality Assurance Filter QA-2	4-25
4-11	Group I Average Elemental Concentrations for the Four Size Ranges Sampled	4-27
4-12	Group II Average Elemental Concentrations for the Four Size Ranges Sampled	4-28

TABLES (continued)

<u>Number</u>		<u>Page</u>
4-13	Group III Average Elemental Concentrations for the Four Size Ranges Sampled	4-29
4-14	Normalization of Elemental Concentrations to Si for Plants A, B, and C	4-56
4-15	Group I Average Trace Element Emission Rates and Factors for the Four Size Ranges Sampled	4-58
4-16	Group II Average Trace Element Emission Rates and Factors for the Four Size Ranges Sampled at Plant C	4-59
4-17	Group II Average Trace Element Emission Rates and Factors for the Four Size Ranges Sampled at Plant E	4-60
4-18	Group III Average Trace Element Emission Rates and Factors for the Four Size Ranges Sampled at Plant A	4-61
4-19	Group III Average Trace Element Emission Rates and Factors for the Four Size Ranges Sampled at Plant D	4-62
4-20	Group I Sulfur Emission Data	4-64
4-21	Group II Sulfur Emission Data	4-65
4-22	Group III Sulfur Emission Data	4-66
4-23	Group I Nitrogen Oxide Emission Factors and Emission Rates Determined From Continuous Monitoring Data	4-74
4-24	Group II Nitrogen Oxide Emission Factors and Emission Rates Determined From Continuous Monitoring Data	4-75
4-25	Group III Nitrogen Oxide Emission Factors and Emission Rates Determined From Continuous Monitoring Data	4-76
4-26	Group I - Chloride Emission Factors and Emission Rates Determined From Analysis of CCS Samples	4-79
4-27	Group II - Chloride Emission Factors and Emission Rates Determined From Analysis of CCS and Coal Samples	4-80

TABLES (continued)

<u>Number</u>		<u>Page</u>
4-28	Group III - Chloride Emission Factors and Emission Rates Determined From Analysis of CCS and Coal Samples	4-81
4-29	Group I - Fluoride Emission Factors and Emission Rates Determined From Analysis of CCS Samples	4-85
4-30	Group II - Fluoride Emission Factors and Emission Rates Determined From Analysis of CCS Samples	4-86
4-31	Group III - Fluoride Emission Factors and Emission Rates Determined From Analysis of CCS Samples	4-87
5-1	Group I - Monthly Power Plants Filterable Particulate Mass Emission Rate	5-4
5-2	Group II - Monthly Power Plants Filterable Particulate Mass Emission Rate	5-5
5-3	Group III - Monthly Power Plants Filterable Particulate Mass Emission Rate	5-6
5-4	Group I - Monthly Sulfur Dioxide Mass Emission Rate	5-12
5-5	Group II - Monthly Sulfur Dioxide Mass Emission Rate	5-13
5-6	Group III - Monthly Sulfur Dioxide Mass Emission Rate	5-14
5-7	Group I - Monthly Sulfuric Acid Mass Emission Rate	5-21
5-8	Group II - Monthly Sulfuric Acid Mass Emission Rate	5-22
5-9	Group III - Monthly Sulfuric Acid Mass Emission Rate	5-23
5-10	Group I - Monthly Sulfate Mass Emission Rate	5-32
5-11	Group II - Monthly Sulfate Mass Emission Rate	5-33
5-12	Group III - Monthly Sulfate Mass Emission Rate	5-34
5-13	Group I - Nitrogen Dioxide (NO ₂) Mass Emission Rate	5-38

TABLES (continued)

<u>Number</u>		<u>Page</u>
5-14	Group II - Nitrogen Dioxide (NO_2) Mass Emission Rate	5-39
5-15	Group III - Nitrogen Dioxide (NO_2) Mass Emission Rate	5-40
5-16	Group I - Nitrogen Oxide (NO_x) Mass Emission Rate	5-41
5-17	Group II - Nitrogen Oxide (NO_x) Mass Emission Rate	5-42
5-18	Group III - Nitrogen Oxide (NO_x) Mass Emission Rate	5-43
5-19	Group I - Monthly Particulate Chloride Mass Emission Rate	5-53
5-20	Group II - Monthly Particulate Chloride Mass Emission Rate	5-54
5-21	Group III - Monthly Particulate Chloride Mass Emission Rate	5-55
5-22	Group I - Monthly Gaseous HCl Mass Emission Rate	5-56
5-23	Group II - Monthly Gaseous HCl Mass Emission Rate	5-57
5-24	Group III - Monthly Gaseous HCl Mass Emission Rate	5-58
5-25	Group I - Monthly Particulate Fluoride Mass Emission Rate	5-68
5-26	Group II - Monthly Particulate Fluoride Mass Emission Rate	5-69
5-27	Group III - Monthly Particulate Fluoride Mass Emission Rate	5-70
5-28	Group I - Monthly Gaseous HF Mass Emission Rate	5-71
5-29	Group II - Monthly Gaseous HF Mass Emission Rate	5-72
5-30	Group III - Monthly Gaseous HF Mass Emission Rate	5-73

TABLES (continued)

<u>Number</u>		<u>Page</u>
6-1	Plants Scheduled to Come On Line by the End of 1983 and Their Projected Particulate Pollutant Mass Emission Rates	6-2
6-2	Plants Scheduled to Come On Line by the End of 1983 and Their Projected Gaseous Pollutant Mass Emission Rates	6-3

SECTION 1

INTRODUCTION

In an effort to better understand the relative contribution to the ambient air quality attributable to emissions from coal-fired power plants, the Environmental Protection Agency (EPA) is conducting a two-phase concurrent study in the Ohio River Valley. The first phase involves the selection of representative coal-fired boilers that typify emissions from units currently in use and those to be brought on line prior to the end of 1983. This phase will provide source emission data for the second phase of the project: an ambient monitoring placement study to be conducted over a 3- to 5-year period. This particular study presents the results of the first phase.

The information presented in this report is representative of emissions from power plants operating in the Ohio River Valley. The results of this report should not be used to estimate emissions for power plants located outside the Ohio River Valley Region.

In the source emission study, five representative units were selected for testing. The constituents measured were total filterable particulate (particulate fractions were calculated by particulate sizing and elemental analysis was conducted for

particle size fractions), particulate sulfate, sulfuric acid mist (H_2SO_4), sulfur dioxide (SO_2), particulate and gaseous chlorides, and particulate and gaseous fluorides (sampled by manual methods); and sulfur dioxide (SO_2), carbon dioxide (CO_2), nitrogen oxides (NO and NO_x), and oxygen (O_2) (sampled by continuous monitors).

This report presents the selection strategy utilized to choose the five test sites, a description of the plants tested, the sampling and analytical techniques employed, and a summary of the data obtained. In addition, the pollutant emissions were projected for the study region for those power plants presently operating and those which will come on line by the end of 1983.

SECTION 2

SITE SELECTION AND PROCESS DESCRIPTIONS

The sites selected for emission testing were determined through several subsequent steps. First, the geographical study limits were determined; then several important selection criteria were applied to the units within that region. This section describes the methodology for plant selection and the criteria utilized for selection.

GEOGRAPHICAL LIMITS OF STUDY

The EPA had previously determined that the study area would consist of the stretch of the Ohio River from Portsmouth, Ohio, to Louisville, Kentucky. This area was chosen because it probably represents the most active region of coal-fired power plants in the country. This region has 45 coal-fired power plant boilers in operation, and another 17 units either under construction or planned. Figure 2-1 presents the geographical locations of the existing and future power plant installations (with capacities >50 MW) on this stretch of the river. The river mile points of 350 and 650 represent natural "break points" for the longitudinal study limits. The two countywide area shown in Figure 2-1 was selected as the latitudinal limits because few (if

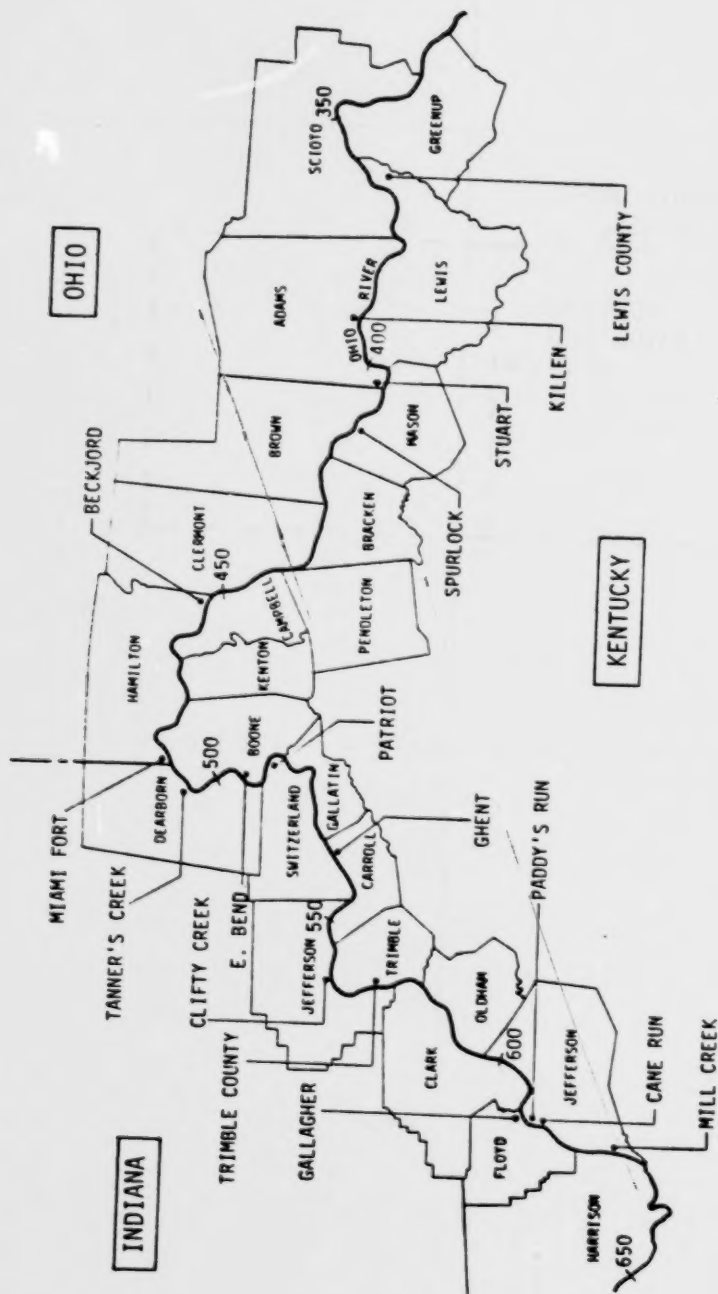


Figure 2-1. Coal-fired power plants located in the study area along the Ohio River.

any) power plants are scheduled to be located beyond these limits and because the impact of emissions is greatest along the narrow river valley.

BOILER CRITERIA

Table 2-1 presents data on the coal-fired power plants in the study region. Most of these units employ particulate control, several are to be retired soon, and several are under construction or beyond the scope of this project (scheduled for completion after 1983).

The selection criteria for site visits and testing consisted of the following essential factors:

- Size of unit
- Age and condition of unit
- Furnace type and burner arrangement
- Load pattern
- Emission control system
- Operating status (e.g., retirement, emergency only)
- Fuel characteristics
- Sampling port availability
- Utility receptiveness
- Design and control of future units
- Concurrent coordination with the ambient monitor placement project

By elimination of gas turbines and those coal boilers soon to be retired, the potential visit list was reduced. The boiler selection criteria consisted of two types: those criteria that could be addressed through the use of in-house data, and those that had to be gathered through a site visit.

Because of incomplete in-house data, sites were visited to acquire information regarding furnace type and burner arrangement, load pattern, sampling port availability and utility

TABLE 2-1. COAL-FIRED POWER PLANTS IN THE OHIO RIVER STUDY REGION^a

Plant/utility	No. of units/size, MWe	In-service date	Particulate control equipment	SO ₂ control equipment	Comments
Killen/DP&L	1/661	1985	ESP ^b	No	Scheduled for completion after 1983
	2/661	1982	ESP	No	
Stuart/DP&L	1/610	1971	ESP	No	Untestable
	2/610	1970	ESP	No	
	3/610	1972	ESP	No	
	4/610	1974	ESP	No	
Spurlock/E. KY	1/300	1977	ESP	No	Untestable
	2/508	1981	ESP	Yes	
Beckjord/CG&E	1/115	1952	ESP	No	
	2/112.5	1953	MCC & ESP	No	
	3/(125)	1954	ESP	No	
	4/163	1958	ESP	No	
	5/244	1962	ESP	No	
	6/460	1969	ESP	No	
	4GT/245 ^d	d	d	d	
Miami Fort/CG&E	3/65	1938	None	No	The plant's three oil-fired boilers will soon be retired The plant's four oil-fired boilers will soon be retired
	4/65	1942	None	No	
	5/100	1949	None	No	
	6/168	1960	MCC & ESP	No	
	7/500	1975	ESP	No	
	8/500	1978	ESP	No	
	6T/207 ^d	d	d	d	
Tanner's Creek/Indiana & Michigan Utilities	1/150	1951	ESP	No	
	2/150	1952	ESP	No	
	3/215	1954	ESP	No	
	4/500	1964	ESP	No	
East Bend/CG&E	1/669	1985	ESP	No	Scheduled for completion after 1983
	2/669	1981	ESP	Yes	
Ghent/Ky. Utilities	1/511	1973	ESP	No	Untestable
	2/511	1977	ESP	No	
	3/511	1981	ESP	No	
	4/511	1983	ESP	No	
Lewis Co./Ky. Power	1/1300	1986	ESP	Yes	Scheduled for completion after 1983
	2/1300	1986	ESP	Yes	

(continued)

TABLE 2-1 (Continued).

Plant/utility	No. of units/size, MWe	In-service date	Particulate control equipment	SO ₂ control equipment	Comments
Clifty Creek/Indiana- Kentucky Utilities	1/225	1955	MC & ESP	No	
	2/225	1955	MC & ESP	No	
	3/225	1955	MC & ESP	No	
	4/225	1955	MC & ESP	No	
	5/225	1955	MC & ESP	No	
	6/225	1956	MC & ESP	No	
Trimble Co./LG&E	1/507	1984	ESP	Yes	Scheduled for completion after 1983
	2/507	1985	ESP	Yes	Scheduled for completion after 1983
	3/675	1988	ESP	Yes	Scheduled for completion after 1983
	4/675	1990	ESP	Yes	Scheduled for completion after 1983
Patriot/Indiana P&L	1/640	1987	ESP	Yes	Scheduled for completion after 1983
	2/650	1985	ESP	Yes	Scheduled for completion after 1983
	3/650	1989	ESP	Yes	Scheduled for completion after 1983
Gallagher/Public Service of Indiana	1/150	1958	ESP	No	
	2/150	1959	ESP	No	
	3/150	1960	ESP	No	
	4/150	1961	ESP	No	
Paddy's Run/LG&E	1/25	1942	ESP	No	Units 1, 2, and 3 will be retired in retired in 1981
	2/25	1942	ESP	No	
	3/69	1947	ESP	No	
	4/69	1949	ESP	No	Units 4 and 5 will be retired in the early 1980's
	5/71	1950	ESP	No	
	6/71	1952	ESP	CE ^e (lime)	
Cane Run/LG&E	1/112.5	1954	ESP	No	Units 1, 2, and 3 will be retired in the early 1980's
	2/112.5	1956	ESP	No	
	3/147.1	1958	ESP	No	
	4/178	1962	ESP	AAF ^f (lime)	
	5/183	1966	ESP	CE (lime)	
	6/277	1969	ESP	CE (DA)	
Mill Creek/LG&E	1/335	1972	ESP	CE ^g (lime/ limestone)	Untestable
	2/326	1974	ESP	AAF (lime)	
	3/425	1977	ESP	AAF (lime)	
	4/495	1982	ESP	AAF (lime)	

^aData for the table is from the FRC Form 67 submitted by the utilities.

^bElectrostatic precipitator.

^cMechanical collector.

^dGas turbine data not available.

^eCombustion Engineering.

^fAmerican Air Filter.

^gDouble alkaline.

receptiveness. A survey form developed to ascertain this information is presented in Appendix A.

All available data were used to narrow the list of test units. Several common characteristics were found when boilers were grouped according to the following age categories:

- Group I: 25 years or older
- Group II: 10 to 25 years old
- Group III: less than 10 years old

Further, the relative size of the units in these age categories was similar. Group I ranged from 69 to 215 MW (113 MW average); Group II from 150 to 225 MW (192 MW average); and Group III from 277 to 610 MW (469 MW average).

Units in the region were reviewed to determine if they might represent the anticipated emission levels from units to be on line in 1983. Table 2-2 shows the generating capacity of the power plants along 50-mile sections of the study area from 1978 to 1983 and the type of control methods utilized in each area. Certain regions will be affected to a much greater extent than other areas from the new plants that will be going on line.

Figure 2-2 depicts the total generating capacity of the study region for each year from 1978 to 1983. The figure shows the amount of total power that was generated by plants operating with particulate control equipment only and the amount that was generated by plants operating with both particulate and SO₂ control equipment. Most of the plants presently under construction will be equipped with particulate and SO₂ control equipment.

TABLE 2-2. GENERATING CAPACITY (MWe) OF POWER PLANTS AT
DIFFERENT GEOGRAPHICAL LOCATIONS ALONG THE OHIO RIVER

Service year	Type of control	Geographical location on the river (miles)						
		350 to 400	400 to 450	450 to 500	500 to 550	550 to 600	600 to 650	
1978	Particulate		2740	3503	1022	1350	1233	
	Particulate and SO ₂						1795	
1979	Particulate		2740	3503	1022	1350	1233	
	Particulate and SO ₂						1795	
1980	Particulate		2740	3503	1022	1350	1233	
	Particulate and SO ₂		508				1795	
1981	Particulate		2740	3503	1533	1350	1045	
	Particulate and SO ₂		508		669		1795	
1982	Particulate	661	2740	3503	1533	1350	1045	
	Particulate and SO ₂		508		669		2366	
1983	Particulate	661	2740	3503	2044	1350	971	
	Particulate and SO ₂		508		669		2366	

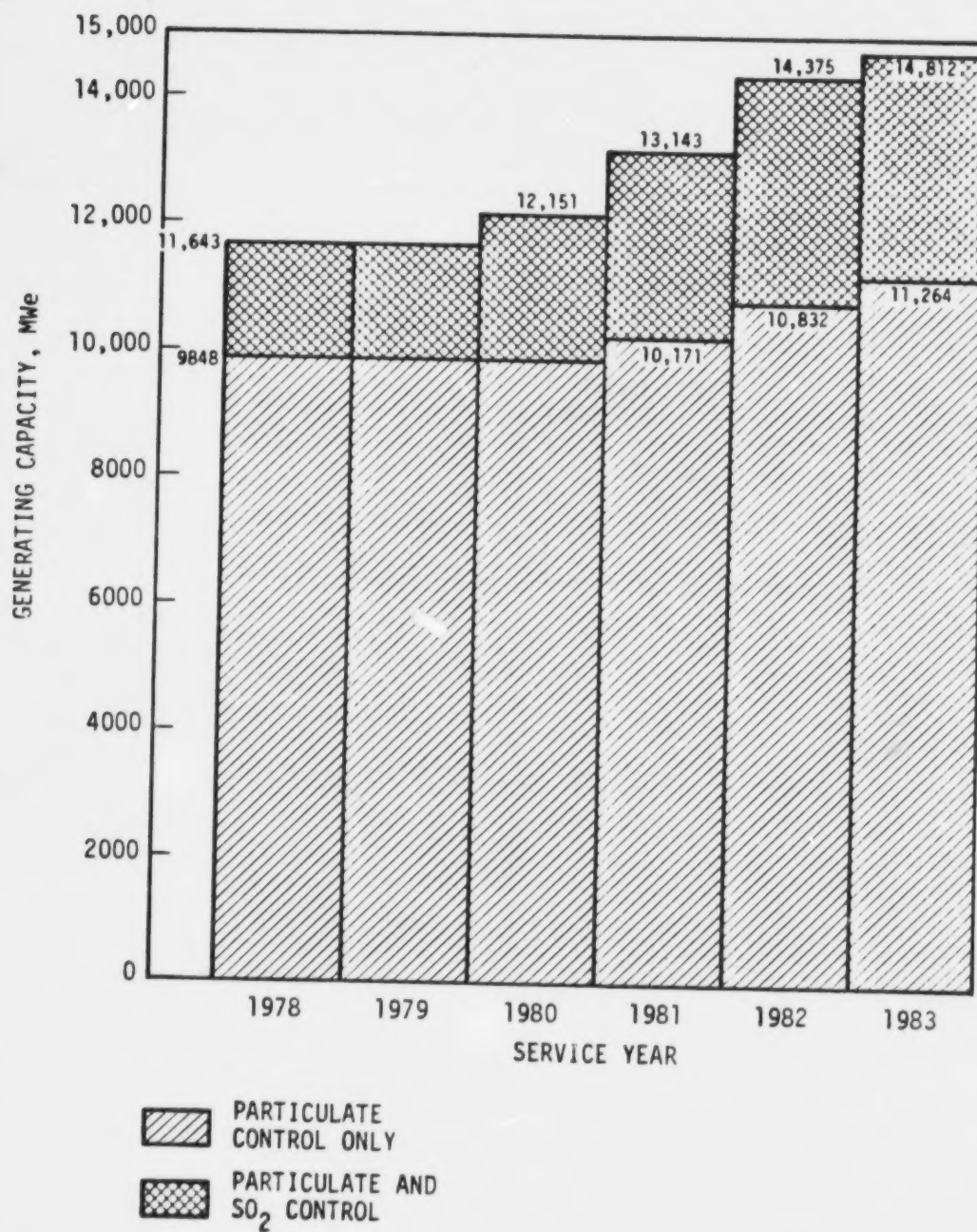


Figure 2-2. Total generating capacity of the study region.

Based on these inputs, five potential test sites were identified. One unit was selected from Group I and two units each were selected from Groups II and III. The unit selected from Group I typifies boilers of that era. The four units selected as representative of Groups II and III are typical of that size category. One unit from Group II and one from Group III are equipped with control devices for controlling particulate emissions only. The other two units in Groups II and III are equipped with full particulate and SO₂ control devices. The lettering system used to designate each plant that participated in the project indicates the order in which the plants were tested.

Plant A was selected from Group III described in the plant selection procedure. The unit tested has a rated nameplate generating capacity of 560 MW and was placed into service in 1970. This Babcock and Wilcox unit has an opposed-fired burner configuration and is equipped with a Buell weighted wire electrostatic precipitator (ESP) to control particulate emissions.

Plant B, which was selected from Group I, has a rated nameplate generating capacity of 125 MW and was placed into service in 1954. This Babcock and Wilcox unit has a front-fired burner configuration and is equipped with a retrofit Research Cottrell ESP installed in 1973 to control particulate emissions.

Plant C, which was selected from Group II, has a rated nameplate generating capacity of 163 MW and was placed into service in 1958. This Combustion Engineering unit has a tangential-fired

burner configuration. The particulate emission control system consists of two ESP's in series. The newer retrofit Research Cottrell ESP was installed in 1975.

Plant D represented Group III of the plants described in the plant selection procedure. The unit tested has a rated nameplate generating capacity of 411 MW and was placed into service in 1978. This Babcock and Wilcox unit has an opposed-fired burner configuration. The air pollution control equipment consists of an American Air Filter (AAF) rigid frame ESP that was installed in 1978. After passing through the ESP, the flue gas enters a carbide lime mobile bed flue gas desulfurization (FGD) system, which was also installed in 1978 by AAF.

Plant E from Group II has a rated nameplate generating capacity of 156 MW and was placed into service in 1962. This Combustion Engineering unit has a horizontal-fired burner configuration. The air pollution control equipment consists of a Research Cottrell weighted wire ESP installed in 1962. After passing through the ESP, the flue gas enters an AAF lime slurry FGD system, which was installed in 1976. Appendix B presents the operating data for each plant during the testing period.

SECTION 3

SAMPLING METHODS AND LOCATIONS

Both manual and continuous sampling methods were used to obtain emission data for the various pollutants. Table 3-1 lists the sampling methods and number of test runs conducted at each plant.

During onsite testing, the power plants operated in a normal manner with the loads changing according to demand. Tests were conducted over at least a 5-day sampling period in an effort to obtain emission data under a number of operating conditions. Manual sampling was performed at the outlets of the air pollution control devices only. Sampling locations at each plant are presented in Appendix C.

Particulate emissions were determined by using EPA Method 5. Samples were collected at a filter and probe temperature of approximately 120°C. All particulate data presented in this report are based on filterable particulate. Filterable particulate consists of the material caught in the probe and filter portion of the EPA Method 5 sampling train. The material (condensibles) captured in the impinger section of the sampling train was not included. Stack gas flow rates determined during the Method 5 tests were used to calculate the mass emission rates of all the pollutants sampled.

TABLE 3-1. SAMPLING METHODS AND NUMBER OF RUNS PER POLLUTANT FOR EACH BOILER

Test method	Pollutant	No. of runs on each of the 5 test days
Manual		
EPA Method 5 (and Methods 1 through 4)	Particulate	2
In-stack impactor	Particle size	2
In-stack impactor	Trace elements	4
CCS ^a	Sulfate (particulate)	2
CCS	H ₂ SO ₄	2
CCS	SO ₂	2
CCS	Chlorides	2
CCS	Fluorides	2
Continuous		
Pulse fluorescence	SO ₂	b
Chemiluminescence	NO	b
Chemiluminescence	NO _x	b
Electrochemical transducer	O ₂	b
Nondispersive infrared	CO ₂	b

^aControlled Condensation System.

^bContinuous sampling during testing period.

Particle size distributions were determined by using an Andersen 2000 Mark III in-stack cascade impactor. This impactor has eight stages and a backup filter, particle size cutoffs range from 0.5 to 15 μm . A standard EPA Method 5 control module was used to maintain isokinetic sampling conditions. The Andersen impactor was also used to obtain particulate samples in various particle size fractions suitable for elemental analysis by X-ray fluorescence (XRF). To determine the particle size distributions, the impactor was run with all eight stages plus a glass fiber backup filter. To obtain samples for elemental analysis, the impactor was assembled with a Zefluor backup filter located at selected stages in the impactor. This sampling method provided samples consisting of particles smaller than the cut-point of the impactor stage preceding the Zefluor filter and a sample on a substrate suitable for XRF analysis. All particle size samples were obtained at a single sampling point located in the stack at a point of average velocity.

The Controlled Condensation System (CCS) was utilized to simultaneously collect and differentiate particulate sulfate, chloride, fluoride, sulfur trioxide (SO_3 as H_2SO_4), sulfur dioxide (SO_2), gaseous hydrogen chloride (HCl), and hydrogen fluoride (HF). The CCS sampling train consists of a heated Vycor probe, a heated quartz filter that collects the particulate matter, a modified Graham condenser that cools the gas below the acid dewpoint to collect the SO_3 (H_2SO_4) vapor, and impingers

that scrub the SO₂, HCl, and HF from the flue gas sample. Samples were obtained at a single point located approximately 1 meter from the stack wall.

The continuous emission monitoring system (CEMS) utilized during this study is shown in Figure 3-1. Table 3-2 lists the monitors used for each pollutant.

Appendix D contains a detailed description of the manual sampling methods and the CEMS used during this test program.

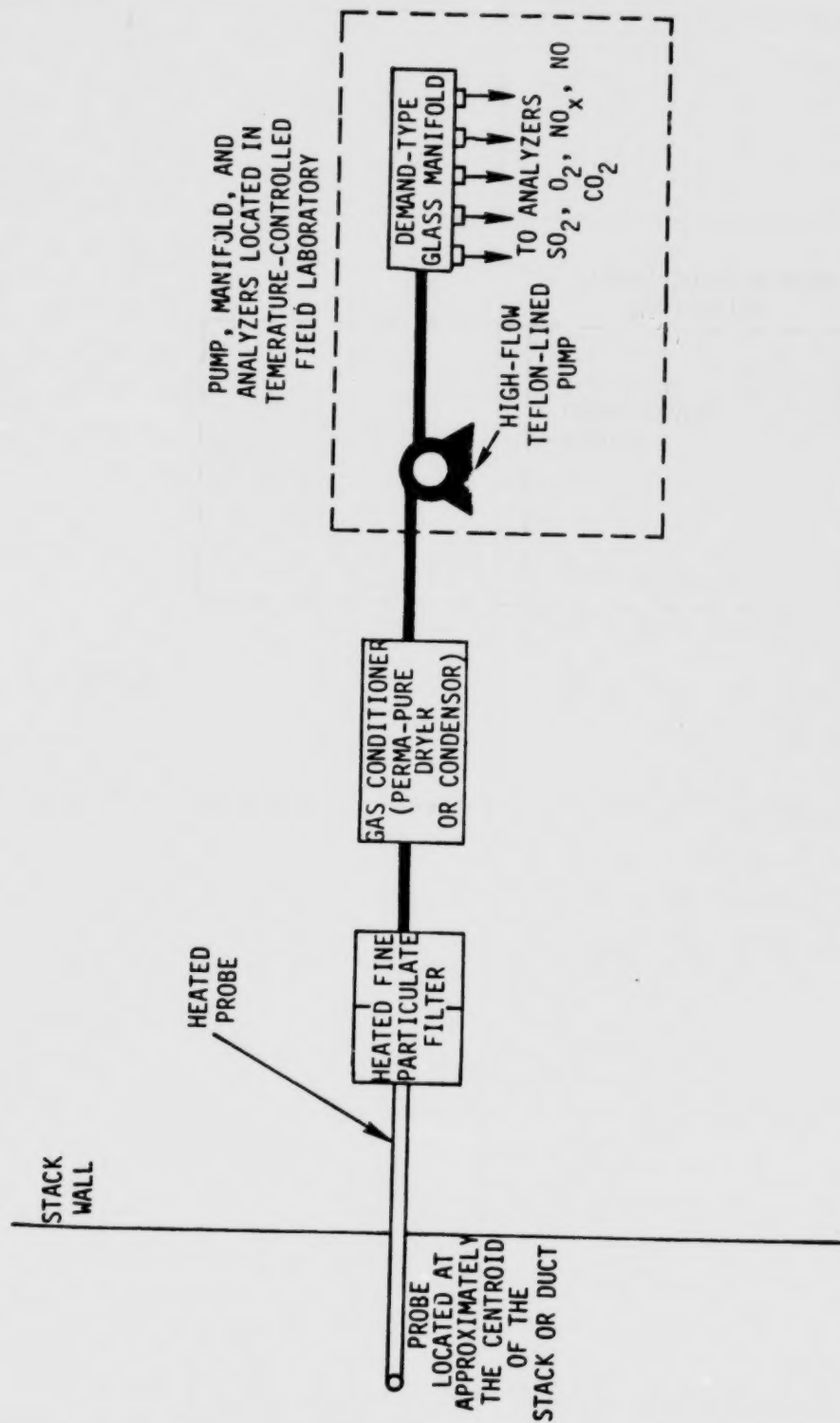


Figure 3-1. Continuous emission monitoring system (CEMS).

TABLE 3-2. CONTINUOUS MONITORS USED FOR
EACH GASEOUS POLLUTANT

Gaseous Species	Principal of Operation of Instruments	Vendor and Model No.
NO _x , NO	Chemiluminescence	TECO 10-A
SO ₂	Pulse fluorescence	TECO 40
CO ₂	Nondispersive infrared	Infra Red Industries 703-352
O ₂	Electrochemical transducer	Theta Sensors 7211-1250

SECTION 4

SUMMARY OF RESULTS

The primary purpose of this study is to provide a comprehensive source emissions characterization for power plants presently operating in the Ohio River Valley and for those that will come on line by the end of 1983. The task was accomplished by developing emission factors by testing a selected group of plants for specific particulate and gaseous pollutants. Tables 4-1 and 4-2 present the emission factors, and the following subsections present emission data and test results.

PARTICULATE EMISSIONS

At each plant tested, Method 5 samples were analyzed to determine total filterable particulate emissions. From these data, the mass emission rates for each test run could be determined, as shown in Tables 4-3 through 4-5. Although analysis of these data shows that the filterable particulate emission rate did not vary according to load, each plant was tested under normal operating procedures, and the load varied with demand. Since the Method 5 tests were conducted over at least a 2-hour sampling period, the load fluctuated considerably in some cases.

An average emission factor was calculated for each plant tested and these values were used to determine the total filterable particulate emission rates for all the coal-fired power

TABLE 4-1. PARTICULATE EMISSION FACTORS

Group	Plant	Type of control	Total particulate, mg/MJ	Inhalable particulate range ^a	Fine particulate range ^b	Particulate chlorides, mg/MJ	Particulate fluorides, mg/MJ	Particulate sulfates, mg/MJ
I	B	ESP	33.2	76.0	34.2	0.04	0.04	0.09
II	C	ESP	490.0	49.2	13.7	0.04	0.04	0.08
II	E	ESP and SO ₂ scrubber	25.8	71.4	39.8	0.04	0.04	0.13
III	A	ESP	85.0	70.9	18.5	0.03	0.06	0.07
III	D	ESP and SO ₂ scrubber	40.7	71.9	40.7	0.04	0.04	0.61

^a Percent of the particulate emissions less than 15 μm in diameter.

^b Percent of the particulate emissions less than 2.5 μm in diameter.

TABLE 4-2. GASEOUS EMISSION FACTORS
(mg/MJ)

Group	Plant	Type of control	SO ₂ ^a	H ₂ SO ₄	NO ₂	NO _x	HCl ^b	HF
I	B	ESP	892	4.8	9.2	278	32.3	3.0
II	C	ESP	735	4.8	10.0	214	41.2	3.3
II	E	ESP and SO ₂ scrubber	576	16.1	5.4	355	0.20	0.10
III	A	ESP	683	2.4	11.8	508	43.7	3.8
III	D	ESP and SO ₂ scrubber	905	19.3	5.3	802	0.82	0.09

^aSO₂ emission factors dependent on sulfur content of coal.

^bHCl emission factors dependent on chlorine content of coal and type of emission controls.

TABLE 4-3. GROUP I - TOTAL FILTERABLE PARTICULATE EMISSION RATES
DETERMINED FROM METHOD 5 SAMPLES

Plant/run	Boiler load, MW	Concentration, ^a mg/dscm	Emission rate,	
			kg/h	mg/MJ ^b
Plant B				
1	85	77	22	43
2	135	85	31	38
3	106	62	21	34
4	97	86	27	43
5 ^c	101	169	53	86
6	95	45	14	26
7	114	66	22	34
8 ^c	102	312	101	159
9	109	48	15	26
10	89	47	12	34
11 ^c	88	307	90	185 ^d
12	95	35	11	21 ^d

^aMeasured at standard conditions: 20°C and 76 cm Hg.

^bBased on F-factor.

^cRuns 5, 8, and 11 showed large weights for the acetone rinses and visually evident contamination resulting from the nozzle scraping against one of the ports.

^dValues were calculated by using an assumed value of 9820 for an F-factor because no coal samples were taken by plant personnel.

TABLE 4-4. GROUP II - TOTAL FILTERABLE PARTICULATE EMISSION RATES
DETERMINED FROM METHOD 5 SAMPLES

Plant/run	Boiler load, MW	Concentration, ^a mg/dscm	Emission rate,	
			kg/h	mg/MJ ^b
Plant C				
1	142	1408	611	64
2	130	1751	630	89
3	150	1514	571	73
4	145	1312	558	66
5	153	1630	694	65
6	147	1290	490	52
7	159	881	344	34
8	162	757	315	29
9	157	693	307	30
10	156	694	291	28
Plant E				
1	170	80	59	30
2	169	74	51	25
3	158	77	57	27
4	174	88	65	26
5	150	87	57	27
6	175	79	57	22
7	175	83	62	25
8	175	89	67	25
9	151	98	66	32
10	175	89	70	25

^aMeasured at standard conditions: 20°C and 76 cm Hg.

^bBased on F-factor.

TABLE 4-5. GROUP III - TOTAL FILTERABLE PARTICULATE EMISSION RATES
DETERMINED FROM METHOD 5 SAMPLES

Plant/run	Boiler load, MW	Concentration, ^a mg/dscm	Emission rate, ^b	
			kg/h	mg/MJ ^b
Plant A				
1	601	373	846	143
2	576	280	598	107
3	590	205	424	71
4	604	302	619	104
5	461	186	346	70
6	602	160	335	59
7	597	167	372	58
8	600	286	627	113
9	602	254	547	94
10	598	238	525	89
11	598	208	461	85
Plant D				
1	346	126	167	47
2	333	90	127	31
3	281	101	121	42
4	399	108	164	38
5	177	74	78	37
6	361	113	159	40
7	372	122	179	45
8	393	128	200	45
9	332	102	141	44
10	339	106	143	39

^a Measured at standard conditions: 20°C and 76 cm Hg.

^b Based on F-factor.

plants in the region of study. Because the plants tested were operating at various times during their periodic scheduled maintenance, the emission factor calculated for an individual plant may be biased high or low, depending on the length of time since the last maintenance outage. For this reason, an average emission factor was calculated to determine the emission rates for all the plants in the study region. The average emission factor calculated for Plant C, however, was not used in determining the average emission factor for the plants tested because this plant was operating abnormally during the testing period, which caused emissions to be much greater than would be expected during normal operations.

The following are the average emission factor and mass emission rate determined for each plant tested according to three selected groups.

Group I

Method 5 testing at Plant B under varying load conditions yielded an average mass emission rate of 19.4 kg/h for filterable particulate. The average emission factor for filterable particulate was determined to be 33 mg/MJ.

Group II

Method 5 testing at Plant C under varying load conditions yielded an average mass emission rate of 481 kg/h for filterable particulate. The average emission factor for filterable particulate was determined to be 530 mg/MJ.

Method 5 testing at Plant E under varying load conditions yielded an average mass emission rate of 61 kg/h for filterable particulate. The average emission factor for filterable particulate was determined to be 25.7 mg/MJ.

Group III

Method 5 testing at Plant A under varying load conditions yielded an average mass emission rate of 535 kg/h for filterable particulate. The average emission factor for filterable particulate was determined to be 92 mg/MJ.

Method 5 testing at Plant D under varying load conditions yielded an average mass emission rate of 159.9 kg/h for filterable particulate. The average emission factor for filterable particulate was determined to be 41.1 mg/MJ.

PARTICLE SIZE DISTRIBUTION

Particle size distribution (PSD) samples were taken with an Andersen Mark III in-stack cascade impactor. All particle size samples were obtained at a single sampling point located in the stack at a point of average velocity. Particle size distribution samples were run simultaneously with the EPA Method 5 tests. The impactor was not heated during the tests at Plants A, B, and C; it was heated at Plants D and E, to prevent moisture from condensing in the impactor. The flow rate through the impactor was maintained in the optimum range for all the sample runs.

Impactor blank runs were performed at each plant to determine if the flue gas reacted with Reeve Angles 934 AH filters. No significant weight changes occurred for any of the test sites.

Data were reduced by use of computer programs detailed in the Cascade Impactor Data Reduction System Manual (EPA-600/7-78-042, March 1978). All particle size distributions are presented by using aerodynamic diameters calculated according to the task group on lung dynamics. This method assumes a particle density of 1 g/cm^3 , calculates a specific Cunningham correction factor, and yields aerodynamic diameters. Results are presented as total mass mean cumulative curves in Figures 4-1 through 4-5.

Comparison of Particle Size Distribution Concentrations With Method 5 Concentrations

Differences in concentrations between the PSD runs and the Method 5 runs varied for each plant. Tables 4-6 shows the results of the comparison. A general relationship can be developed for the plants tested by breaking them down into two groups.

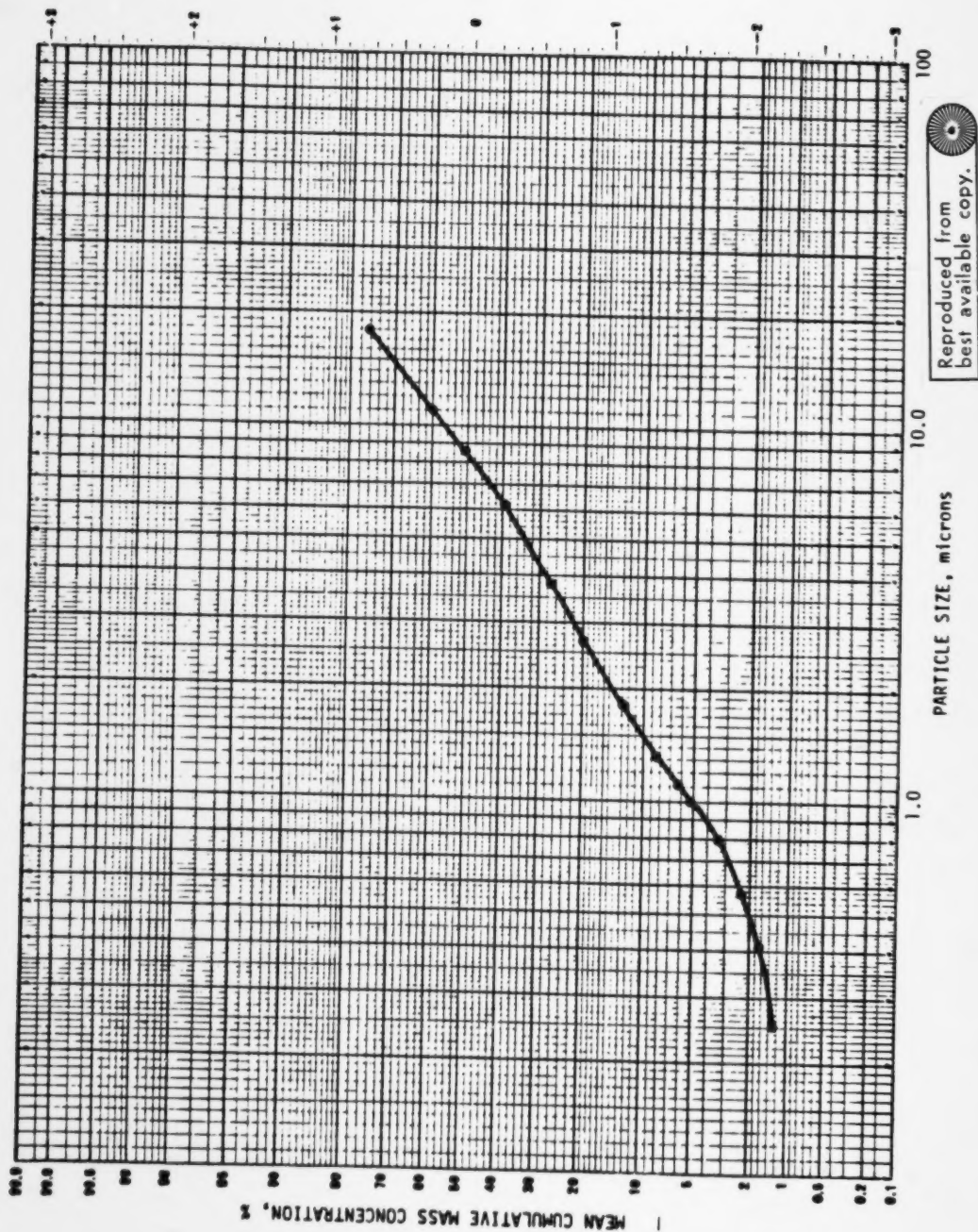


Figure 4-1. Plant A total mass mean cumulative curve.

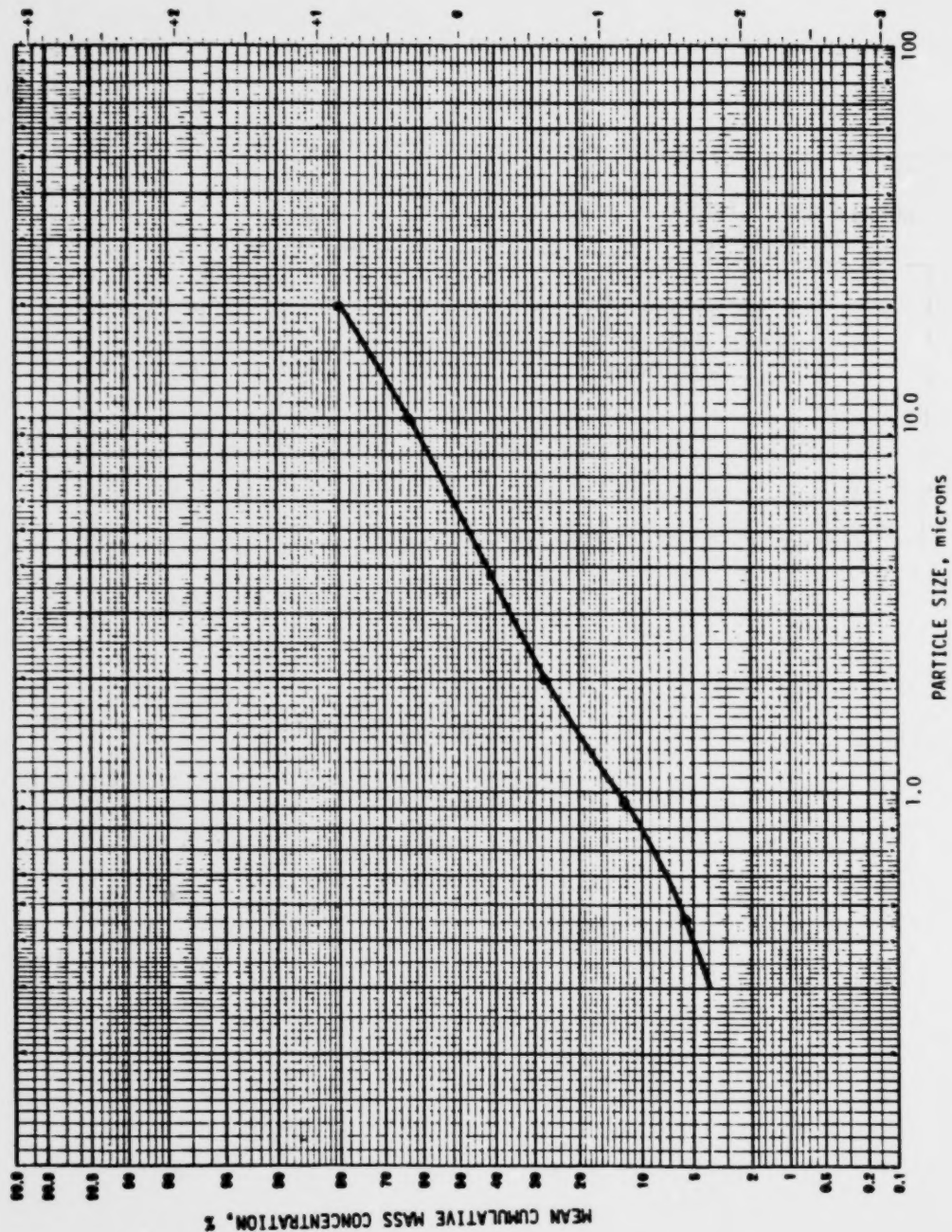


Figure 4-2. Plant B total mass mean cumulative curve.

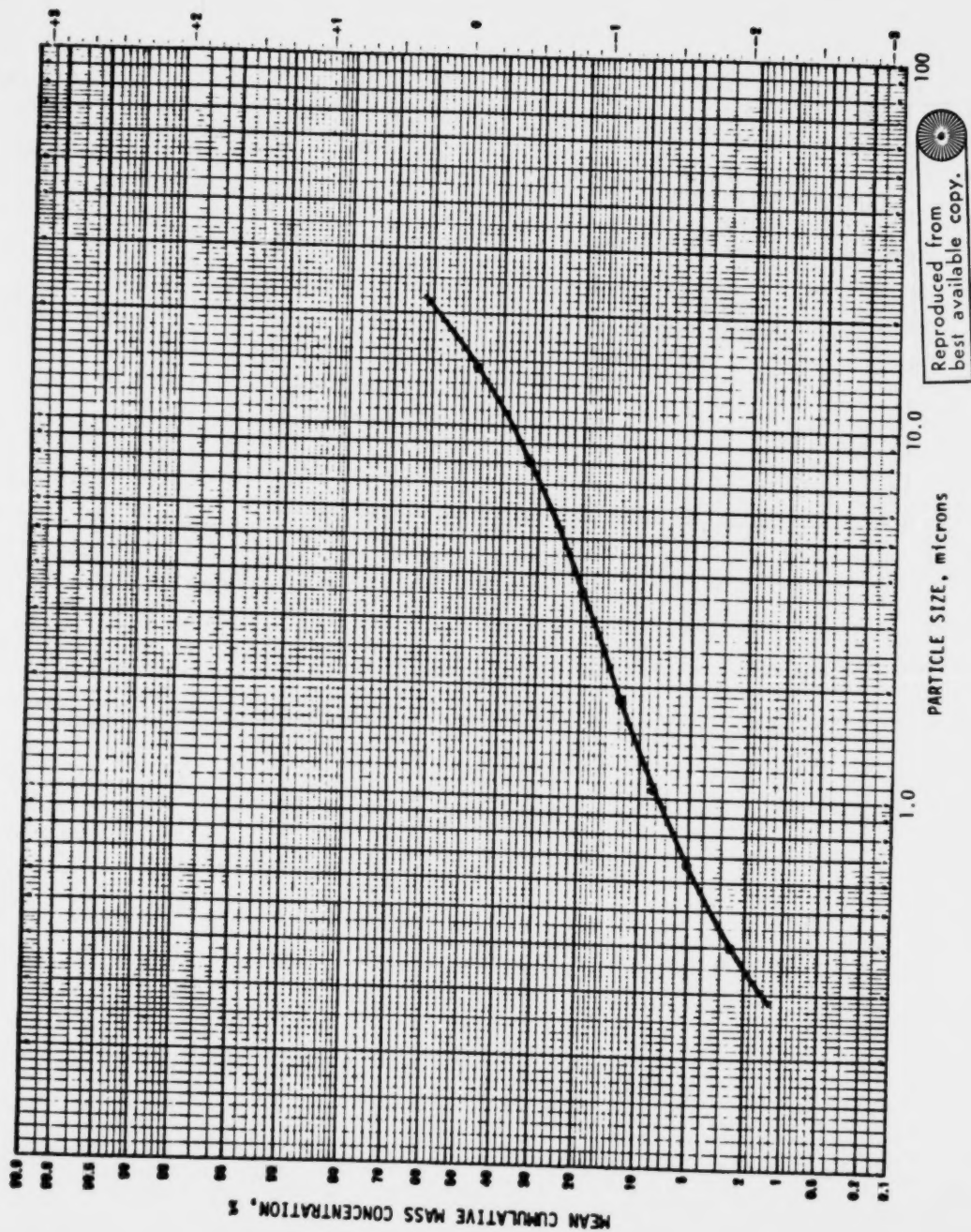


Figure 4-3. Plant C total mass mean cumulative curve.

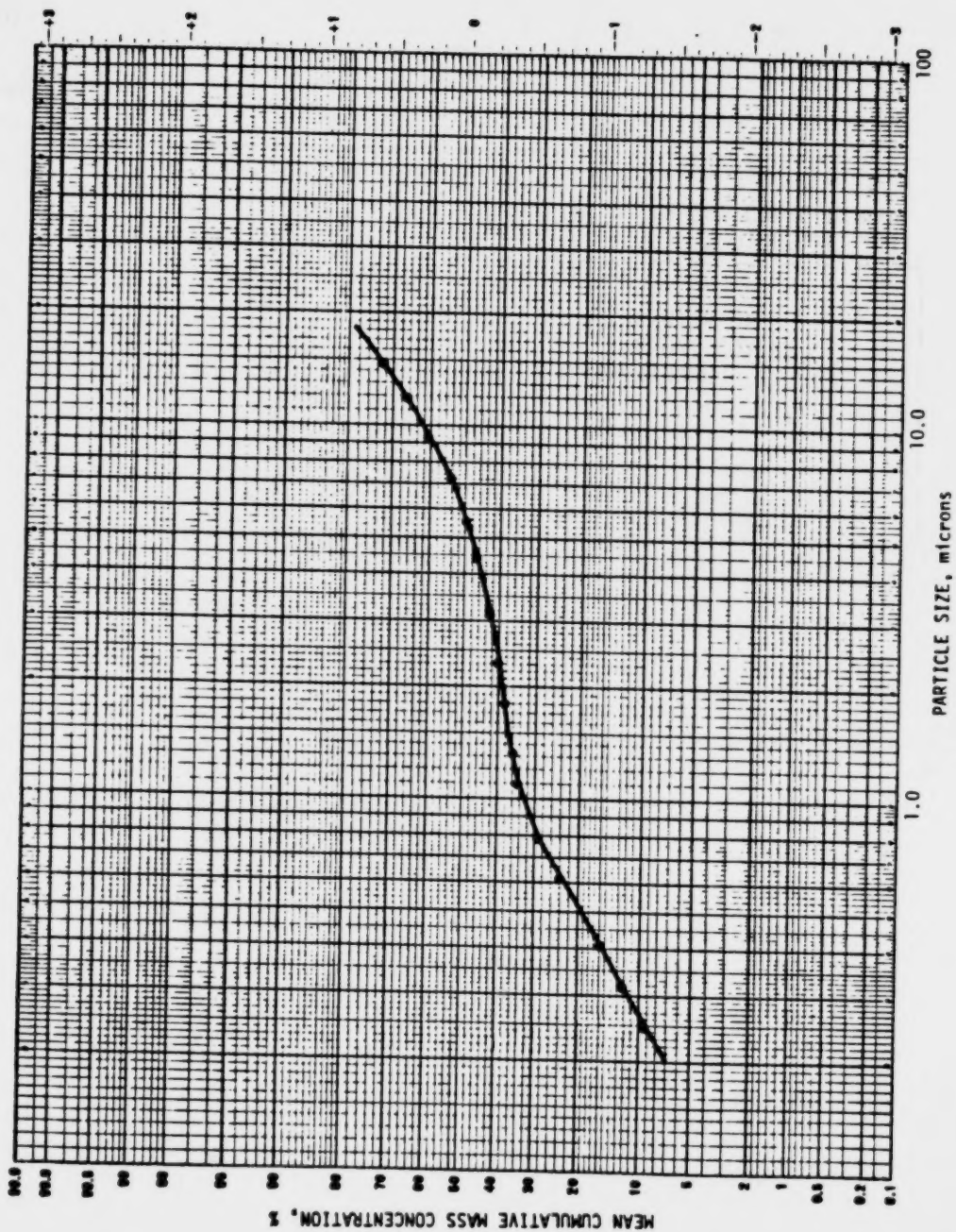


Figure 4-4. Plant D total mass mean cumulative curve.

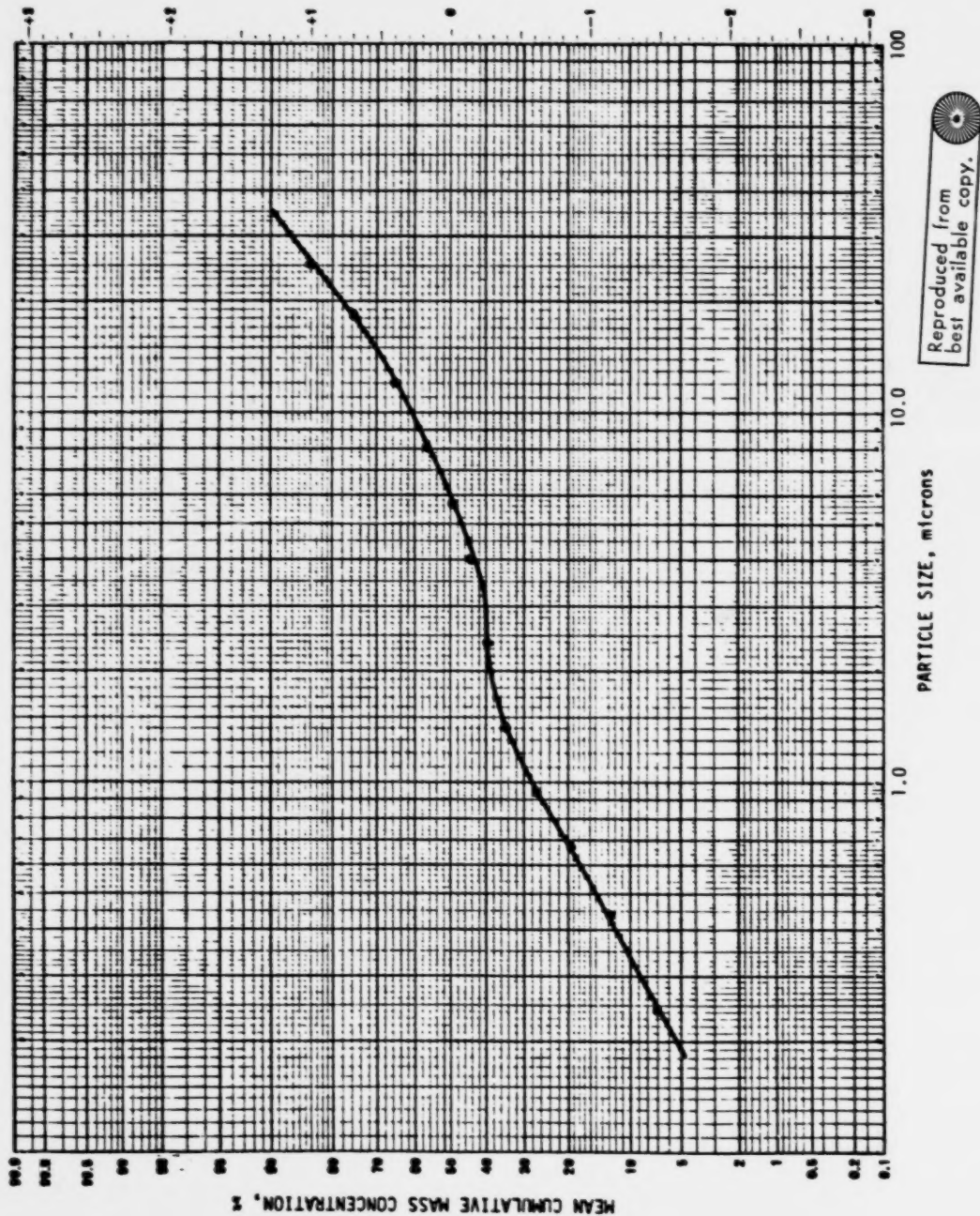


Figure 4-5. Plant E total mass mean cumulative curve.

TABLE 4-6. COMPARISON OF PARTICLE SIZE DISTRIBUTION
CONCENTRATIONS TO METHOD 5 CONCENTRATIONS

Run No.	Total particulate concentration, mg/dscm									
	Plant A		Plant B		Plant C		Plant D		Plant E	
	PSD	Method 5	PSD	Method 5	PSD	Method 5	PSD	Method 5	PSD	Method 5
1	159.4	373.4	64.2	77.2	348.9	1408.6	17.8	126.4	16.5	79.45
2	137.5	279.8	33.3	84.9	657.2	1751.8	25.6	90.4	21.3	73.88
3	184.1	204.8	22.2	62.6	706.8	1514.8	23.9	100.7	20.6	77.19
4	116.3	302.6	29.4	86.5	614.5	1312.7	39.2	107.7	24.4	87.49
5	85.0	186.4	15.2	44.8	1173.4	1631.2	13.7	73.5	21.3	87.21
6	75.5	157.1	40.2	66.1	747.8	1290.2	12.1	112.5	34.7	78.50
7	102.7	166.5	18.1	47.6	527.1	881.7		121.9	29.0	83.23
8	188.9	286.3	22.9	34.6	561.6	757.6		127.5		88.62
9	126.9	254.3				693.5		102.0		97.76
10	140.7	237.9				694.0		106.2		89.41
11	89.0	207.6								
Avg.	127.8	241.5	30.7	61.3	667.2	1193.6	22.1	106.9	24.0	84.3

The first group consists of Plants A, B, and C, whose only emission control device was an ESP. The PSD concentrations for this group averaged 53 percent of the Method 5 concentrations.

The second group consists of Plants D and E, which used both an ESP and a scrubber to control process emissions. The PSD concentrations for this group averaged 25 percent of the Method 5 concentrations.

Comparison of Particle Size Distributions with Varying Load

Results were compared for each plant tested to determine if a correlation existed between particle size distribution and plant operating load. The particle size tests were run at normal plant operating loads, and when the load fluctuated with demand. The different particle size runs show that size variations did occur in the filterable emissions of each plant, but these size variations did not follow any detectable pattern.

Inhalable and Fine Particulates

The particle size distributions were examined for each plant tested to determine what percentage of particulate emissions fell into the range of inhalable and fine particulates. The inhalable particulate (IP) range includes those particles less than 15 μm in diameter. The fine particulate (FP) range includes particles less than 2.5 μm in diameter. Because the cutpoints of the different stages of an Andersen Mark III impactor do not include 15 μm and 2.5 μm , a computer program was used to calculate and extrapolate these values. It was determined that the different loads at which the plant operated during testing did not

significantly affect the particle size distributions. All PSD runs for each separate plant were grouped together, and the average mean cumulative mass concentration was determined for each unit. The computer program extrapolates the best-fit curve for the data supplied and removes outliers. Table 4-7 presents a comparison of the amount of particulate being emitted in the inhalable and fine particulate ranges at each plant.

The values in Table 4-7 show that Plants A, B, D, and E are in fairly good agreement as to the percentage of particulates being emitted in the inhalable range, whereas the percentage for Plant C is much lower. These results further indicate that Plant C was not operating properly during the testing period. The particulate emission rates determined by EPA Method 5 yielded the same results.

For percentages of the particulate being emitted in the fine particulate range, only Plants B, D, and E seem to compare well. The Method 5 results showed that Plants A and C had significantly higher filterable particulate emissions than did Plants B, D, and E. Higher particulate emissions suggest the presence of more layer particles; thus the small percentage of fine particulate. These particle size data also show that Plant C was not removing larger particles ($>15 \mu\text{m}$).

TABLE 4-7. PERCENTAGE OF INHALABLE AND FINE PARTICULATE

Plant	Inhalable particulate (<15 μm), percent less than	Fine particulate (<2.5 μm), percent less than
A	70.9	18.5
B	76.0	34.2
C	49.2	13.7
D	71.9	40.7
E	71.4	39.8

TRACE ELEMENT ANALYSIS

At each plant tested particle size samples were run with the Andersen Mark III impactor by varying the number of filter stages directly in front of the Zeflour backup filter. Four different impactor sampling configurations were used during the sampling period by using two, four, six, and eight impactor stages before the Zeflour backup filter.

The Zeflour backup filters used for the different particle sizing runs were submitted to NEA Laboratories for elemental analysis. The filters for Plants A, B, and C were analyzed for 22 elements by neutron activation analysis (NAA) and x-ray fluorescence (XRF). The filters for Plants D and E were analyzed for these 22 elements and 4 additional elements, P, Ga, Rb, and Sr. Only two elements, Cd and Ba, were not detectable at any concentration in the samples analyzed.

The following is a brief description of the analysis performed by NEA Laboratories.

Air particulate samples of power plant emissions were analyzed by XRF and NAA. The samples were collected on Zeflour filters by using an Andersen Mark III type impactor. The material for particle sizing was collected as a uniform deposit on the backup filter and as a series of spots on the impactor stages. Some of the particles were loosely bound to the filters. The deposit of particles were not uniform, as desired, but were spotted. This is primarily because of the structure of the Zefluor filter and backup plate used to support the filter. The nonuniform deposit of particles on the impaction plates make

quantitative XRF analysis difficult. Other problems with the XRF include the potential effects of particle size, self absorption, and poor sensitivity for elements such as Na and Mg. The combination of XRF and NAA mitigates these problems, improves sensitivity for other elements, and provides additional quality assurance.

The analysis procedure consisted of the following:

1. An XRF analysis including the use of three excitation conditions to maximize the sensitivity for a broad range of elements.
 - a. Mo anode, No filter, 15 KV
Al, Si, S, Cl, K, Ca, Fe, P
 - b. Mo anode, No filter, 50 KV
Fe, Ni, Cu, Zn, As, Se, Br, Cd, Ba, Pb, Ga, Rb, Sr
 - c. W anode, Cu filter, 35 KV
S, K, Ca, Ti, V, Cr, Mn, Fe

About six different areas of the filter were exposed in each excitation.

2. The entire filter was then sealed in polyethylene film and irradiated for 5 minutes in a neutron flux of 2×10^{12} n/sec/cm², allowed to decay for 10 minutes, and counted for 200 seconds. All samples were flux-corrected to standards. Both NBS urban aerosol and USGS BCR-1 standard reference materials were run as quality assurance checks.
3. The neutron activation results were then used as internal standards for the XRF. The NAA/XRF ratio for Ti, V, and Mn were averaged for each filter, and the XRF results were normalized by that factor. The results reported for elements measured by NAA are NAA results, whereas the other elements reported are XRF results normalized as noted above. The Si results were normalized by the Al ratio to avoid particle size and self absorption effects. The Al ratio was used for all of the XRF results if the Ti, V, and Mn NAA values were all below detection limits. No results were reported when all of the NAA results were below detection limits.

A quality assurance sample was run with every 10 filters analyzed by XRF and the results were plotted for Fe in the manner shown in Figure 4-6. The quality assurance results were within 3 percent at the time the instrument was calibrated.

Table 4-8 presents the NAA quality assurance data. Five BCR-1 samples were run as unknowns, and the results were compared to the literature values for the standard reference material (SRM lit.). The results are generally within 10 percent and always within the listed uncertainty values. Table 4-8 also presents a comparison of the results of two urban aerosol samples run as unknowns with the literature values.

PEDCo also performed its own quality control check of NEA Laboratories by submitting two blank filters for analysis. On the first filter analyzed, neither the NAA nor the XRF showed any detectable concentrations. On the second filter analyzed no concentrations were detectable by XRF, but the NAA did show detectable concentrations of some elements, even though their values were very small and could be contributed to background interference. In addition, two filters were submitted with NBS reference materials 1632a and 1633a (coal trace element and fly ash trace element standards). Because only the elements reported in the NEA analysis can be evaluated against the NBS analysis, the standard elements detected by NEA were summed and individual ratios were compared to the corresponding NBS elemental ratio. Tables 4-9 and 4-10 list these ratios.

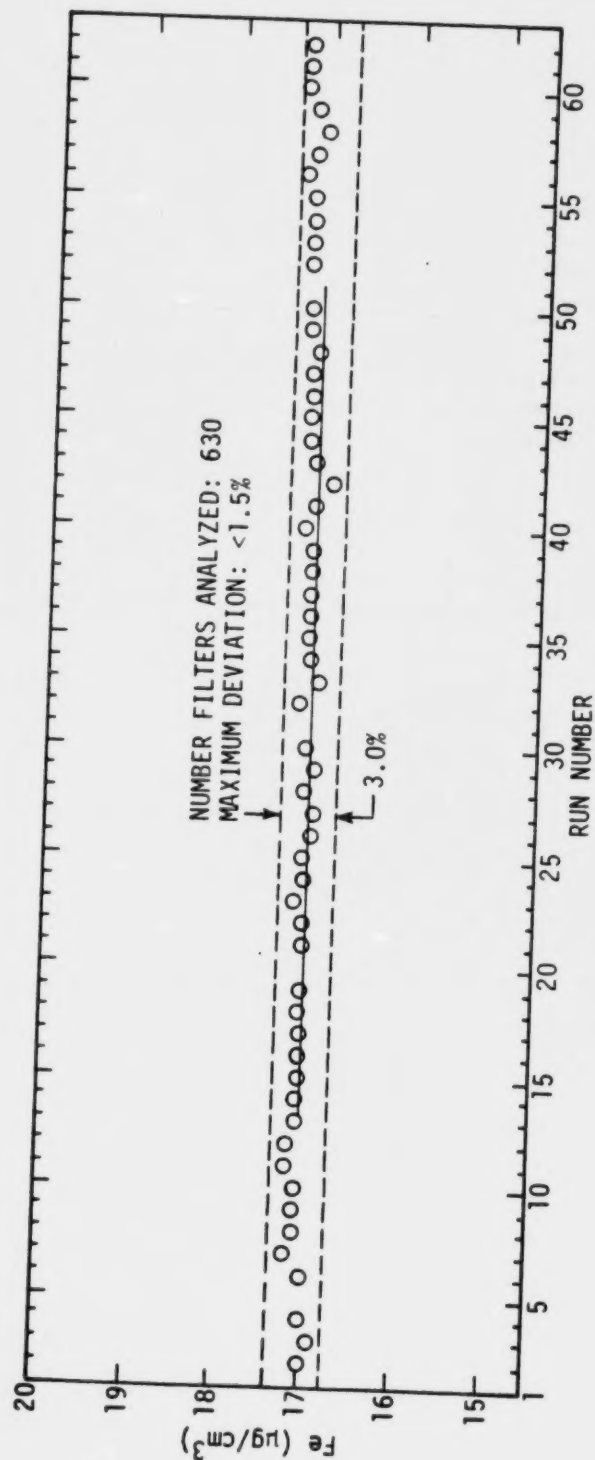


Figure 4-6. X-Ray fluorescence quality control data (XRF-3).

TABLE 4-8. NAA QUALITY ASSURANCE DATA

EL	SRM (lit.)	BCR-1					Avg.
		B040	B041	B042	B043	B044	
Ti%	1.32	1.28 ± 0.07	1.28 ± 0.07	1.47 ± 0.09	1.35 ± 0.08	1.37 ± 0.08	1.35
Br	-	-	-	-	-	-	-
Mg%	2.1	2.17 ± 0.21	2.08 ± 0.19	2.49 ± 0.22	2.09 ± 0.21	2.12 ± 0.21	2.19
Na%	2.38	2.47 ± 0.13	2.43 ± 0.12	2.81 ± 0.15	2.52 ± 0.13	2.58 ± 0.13	2.56 ± 0.15
V	400	423 ± 21	456 ± 23	485 ± 25	438 ± 23	444 ± 23	449 ± 23
Cl	-	-	-	-	-	-	-
Al%	7.2	6.9 ± 0.3	7.47 ± 0.35	8.41 ± 0.41	7.58 ± 0.37	7.80 ± 0.38	7.6 ± 0.6
Mn	1440	1422 ± 77	1606 ± 72	1596 ± 84	1493 ± 80	1550 ± 82	1493 ± 81

Urban Aerosol			
EL	SRM (lit.)	U037	U040
Ti%	0.40 ± 0.02	0.35 ± 0.03	0.35 ± 0.02
Br	500 ± 30	527 ± 31	485 ± 25
Mg%	0.83 ± 0.08	0.86 ± 0.11	0.83 ± 0.07
Na%	0.40 ± 0.02	0.45 ± 0.03	0.39 ± 0.03
V	130 ± 7	134 ± 7	120 ± 6
Cl	0.45 ± 0.02	0.42 ± 0.03	0.41 ± 0.2
Al%	3.5 ± 0.1	3.5 ± 0.17	3.34 ± 0.16
Mn	790 ± 20	757 ± 42	675 ± 35

TABLE 4-9. QUALITY ASSURANCE FILTER QA-1.

NBS Standard Reference Material 1632a, Trace Elements in Coal

Detected element	NBS concentration, $\mu\text{g/g}$	Detected element, %	NEA concentration, $\mu\text{g/filter}$	Detected element, %
V	44	0.39	0.36 ± 0.027	0.49
Mn	28	0.25	0.21 ± 0.047	0.28
Cr	34.4	0.30	0.435 ± 0.43	0.59
Fe	11,100	98.28	71.647 ± 3.658	97.23
Ni	19.4	0.17	0.194 ± 0.032	0.26
Cu	16.5	0.15	0.137 ± 0.034	0.19
Zn	28	0.25	0.318 ± 0.033	0.43
As	9.3	0.08	0.142 ± 0.078	0.19
Se	2.6	0.02	<0.031	<0.04
Pb	12.4	0.11	0.211 ± 0.122	0.29

TABLE 4-10. QUALITY ASSURANCE FILTER QA-2.

NBS Standard Reference Material 1633a, Trace Elements in Coal

Fly ash				
Detected element	NBS concentration, $\mu\text{g/g}$	Detected element, %	NEA concentration, $\mu\text{g/filter}$	Detected element, %
Na	1,700	0.5	2.33	0.78
Mg	4,550	1.3	18.06	6.05
Si	228,000	67.0	234.50	78.50
Ca	11,100	3.3	10.35	3.46
Cr	196	0.06	0.304	0.10
Fe	94,000	27.6	32.42	10.85
Ni	127	0.04	0.131	0.04
Cu	118	0.03	0.144	0.05
Zn	220	0.06	0.121	0.04
As	145	0.04	<0.123	<0.04
Se	103	0.03	<0.048	<0.02
Pb	72.4	0.02	<0.195	<0.07

Upon examination, it is evident that the NEA report quantitatively identified all of the detected elements to within one order of magnitude. Those elements (Na, Mg, and Si) that show a significant deviation within this range are subject to the effects of particle size, self absorption, and poor sensitivity, as stated earlier.

Four different impactor setups were used in obtaining particle size samples for trace element analysis. By varying the number of impactor stages in front of the Zeflour backup filter, the concentration of each element being emitted could be determined for each different size range. The particle size runs for trace elements followed the same sampling procedure as described for sample runs for total particle size distribution (PSD), except for variations in the number of impactor stages prior to the backup filter.

For each size range sampled, total concentrations were determined for all the elements detected on the backup filter. Tables 4-11 through 4-13 presents the average concentration for each element detected in the three defined groups. From this information, the percent of the total concentration for each element can be determined. For Plants A, B, and C, the matrix elements Si, Al, Mg, Fe, and K comprised between 90 and 95 percent of the total elemental concentrations in most cases. For Plants D and E, the primary elements detected were Al, Si, P, S, Ca, and Fe, which comprised between 93 and 97 percent of the total elemental concentration. Figures 4-7 through 4-9 present

TABLE 4-11. GROUP I AVERAGE ELEMENTAL CONCENTRATIONS FOR
THE FOUR SIZE RANGES SAMPLED
($\mu\text{g}/\text{m}^3$)

Element	Plant B size ranges			
	<8.5 μm	<3.8 μm	<0.93 μm	<0.29 μm
Na	40	22	6	< 4
Mg	415	278	22	4
Al	2644	1717	130	22
Si	4327	2739	210	50
S	108	64	12	14
Cl	14	14	4	< 2
K	236	158	14	< 2
Ca	110	80	12	10
Ti	152	102	10	2
V	8	6	< 2	< 2
Cr	10	4	2	< 2
Mn	6	4	< 2	< 2
Fe	597	371	36	14
Ni	6	2	< 2	< 2
Cu	6	4	< 2	< 2
Zn	8	4	< 2	< 2
As	6	4	< 2	< 2
Se	2	2	< 2	< 2
Br	< 2	< 2	< 2	< 2
Pb	4	< 2	< 2	< 2

TABLE 4-12. GROUP II AVERAGE ELEMENTAL CONCENTRATIONS FOR THE
FOUR SIZE RANGES SAMPLED
($\mu\text{g}/\text{m}^3$)

Element	Plant C size ranges				Plant E size ranges			
	<9.81 μm	<4.11 μm	<1.1 μm	<0.38 μm	<8.9 μm	<3.6 μm	<0.98 μm	<0.32 μm
Na	1,331	692	172	43	28	7	19	3
Mg	11,202	5,913	1,587	376	131	36	103	9
Al	59,499	34,058	9,902	2,556	841	226	720	76
Si	103,866	64,752	16,319	4,347	1,681	478	1,502	165
S	1,469	950	340	125	3,566	337	1,073	1,376
Cl	<230	<106	<43	<25	14	4	4	5
K	6,331	4,302	1,043	227	107	31	96	12
Ca	2,546	1,853	499	125	381	134	400	116
Ti	4,388	2,415	608	177	62	20	63	13
V	156	102	30	9	18	5	14	4
Cr	140	114	36	9	7	1	3	1
Mn	66	79	23	5	5	1	4	<1
Fe	12,818	7,741	2,157	420	523	177	578	83
Ni	89	61	16	2	8	1	2	1
Cu	93	81	21	6	2	1	1	1
Zn	120	82	23	7	23	5	12	3
As	66	86	34	8	6	4	3	2
Se	18	18	<5	2	22	1	1	6
Br	<11	<7	<2	<2	3	1	1	<1
Pb	107	29	<13	<7	6	3	3	1
P					202	38	139	68
Ga					1	1	1	<1
Rb					3	1	2	1
Sr					6	1	6	1

TABLE 4-13. GROUP III AVERAGE ELEMENTAL CONCENTRATIONS FOR THE FOUR
SIZE RANGES SAMPLED
($\mu\text{g}/\text{m}^3$)

Element	Plant A size ranges				Plant D size ranges			
	<9.7 μm	<4.0 μm	<1.1 μm	<0.36 μm	<8.3 μm	<3.4 μm	<0.92 μm	<0.30 μm
Na	435	193	13	8	11	10	9	20
Mg	4,271	1,729	151	62	30	20	24	8
Al	26,115	10,420	920	374	195	123	117	44
Si	45,145	17,848	1,565	650	362	151	180	60
S	599	312	115	42	5,327	7,024	3,644	1,279
Cl	<57	<51	<8	<6	19	23	12	6
K	2,547	1,119	115	13	22	21	12	6
Ca	956	459	85	19	103	80	92	27
Ti	1,619	607	62	23	12	9	8	3
V	85	40	8	6	2	2	4	<1
Cr	89	47	11	2	3	1	1	2
Mn	43	25	2	<2	1	1	1	1
Fe	4,331	2,479	206	34	103	94	119	30
Ni	28	21	4	<2	1	1	1	16
Cu	38	17	4	<2	2	1	1	1
Zn	98	30	6	<2	5	4	4	12
As	55	45	11	4	4	2	2	2
Se	11	8	4	<2	59	24	63	25
Br	<4	<2	<2	<2	3	1	1	1
Pb	30	13	2	<2	6	3	2	3
P					195	307	164	64
Ga					1	1	<1	<1
Rb					4	2	1	2
Sr					4	2	1	2

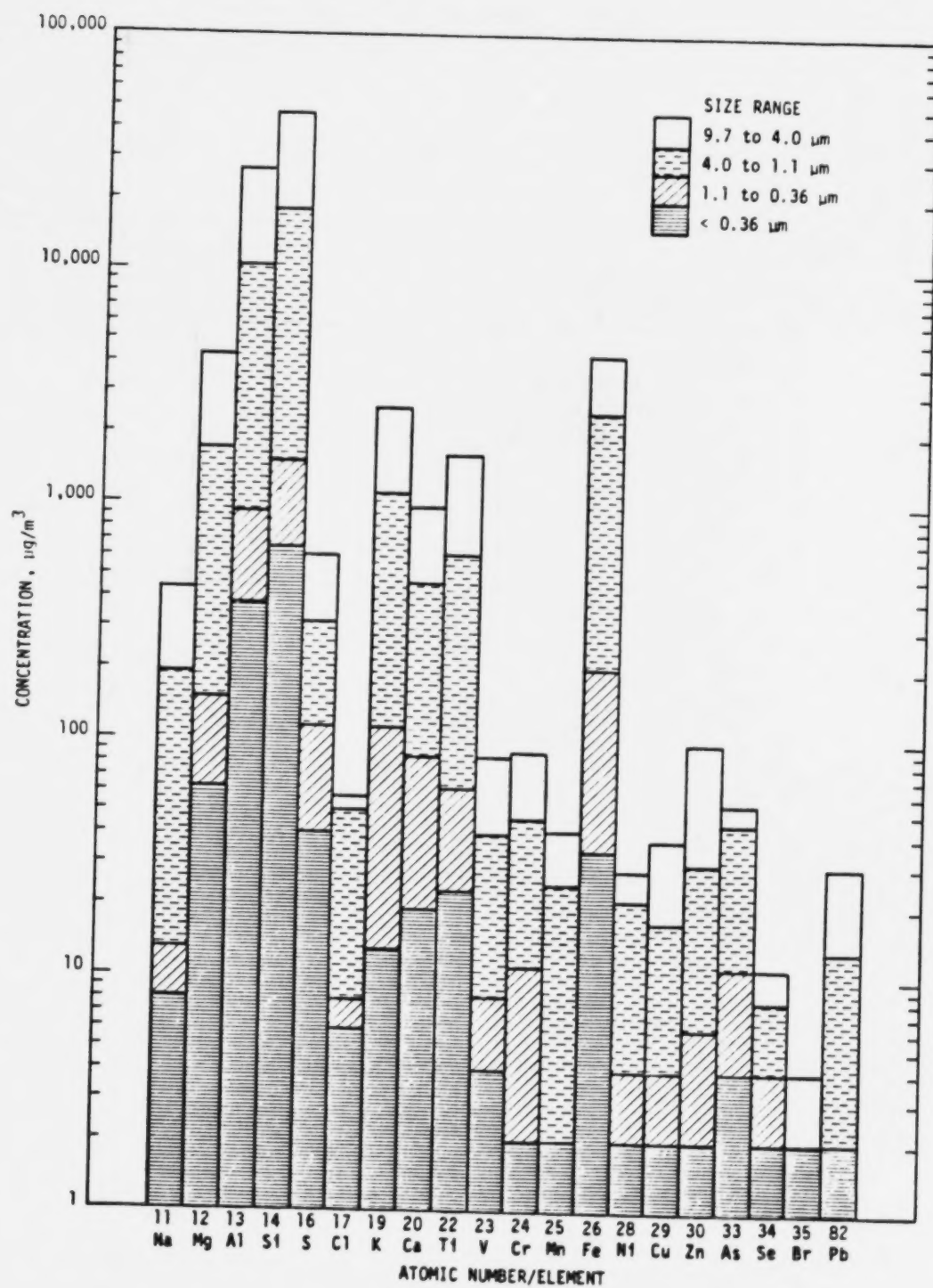


Figure 4-7. Plant A elemental concentration size distribution.

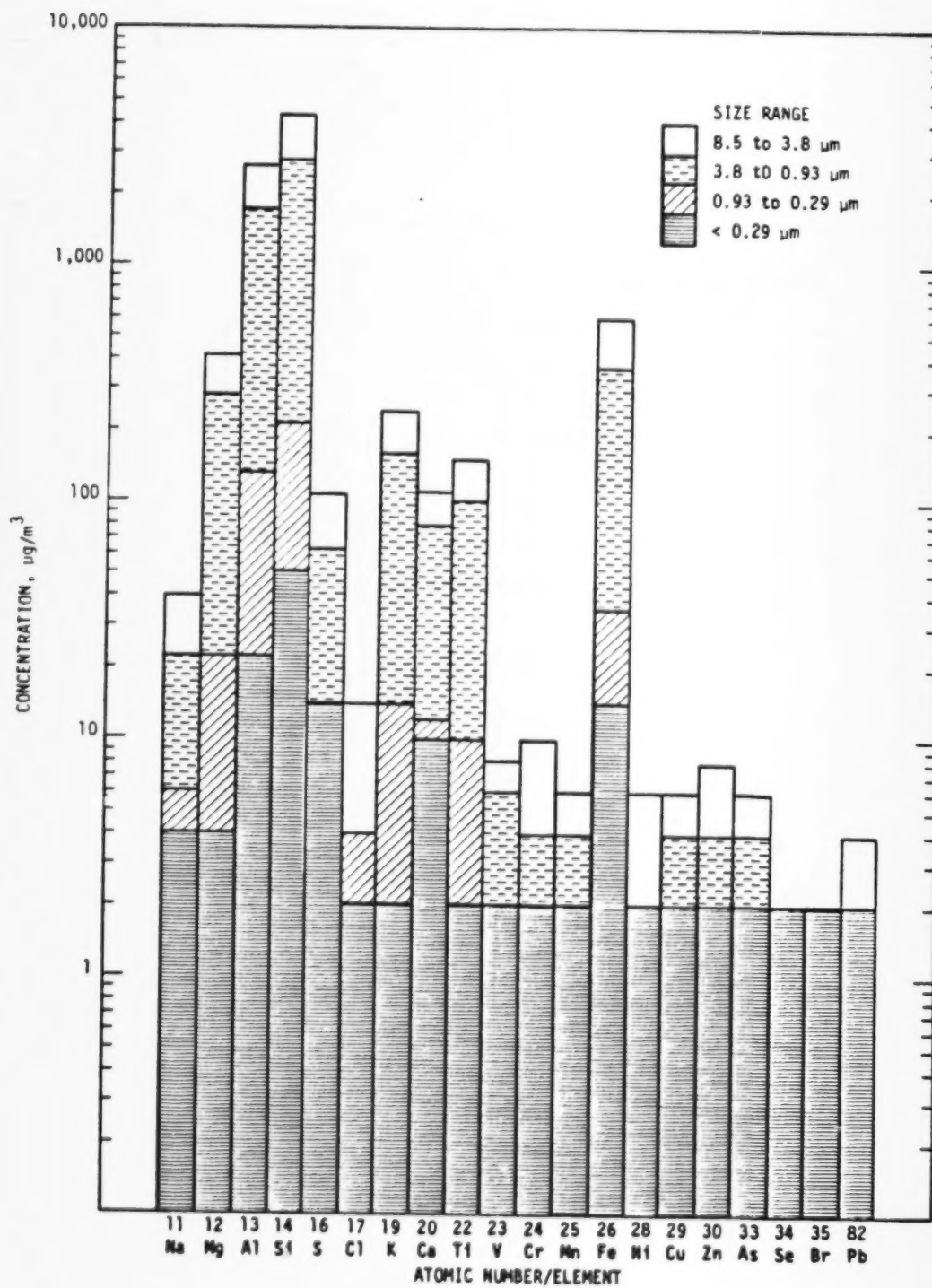


Figure 4-8. Plant B elemental concentration size distribution.

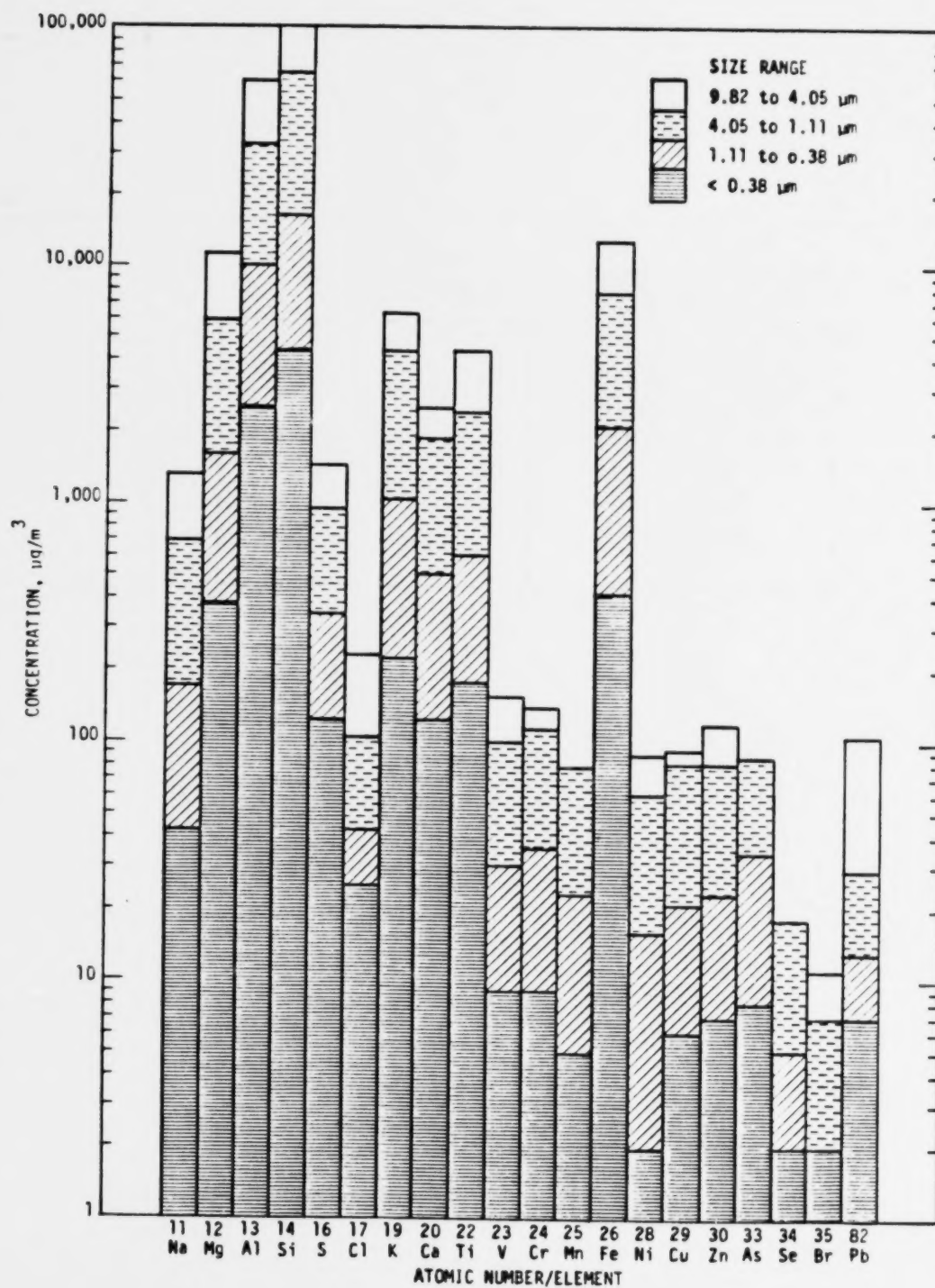


Figure 4-9. Plant C elemental concentration size distribution.

the elemental concentration for each size range in the order of its atomic number for Plants A, B, and C, which operated with an ESP as their only emission control device. The figures show that the shape of the elemental concentration size distribution for Plants A, B, and C compare closely. This indicates that the elemental emissions of Plants A, B, and C are similar.

Figures 4-10 and 4-11 show the maximum concentration for each element, in order of its atomic number, for Plants D and E which have both an ESP and a scrubber to control emissions. Maximum elemental concentrations are presented because the elemental concentrations for the size ranges did not follow a distinguishable pattern and varied for the various size ranges. The shape of the elemental concentration size distribution for Plants D and E indicate a similarity of elemental emissions from these two plants. The results for Plants D and E indicate that the scrubber increases the concentrations of certain elements (e.g., S and Ca).

As a further illustration of the trace element concentration versus particle size, Figures 4-12 through 4-31 present the maximum, average, and minimum element concentration for each size range for all the plants.

Because elemental concentrations varied significantly for Plants A, B, and C, the results of each plant were normalized. Since Si had the greatest elemental concentration at all three plants, it was used as the normalization factor. The results of this normalization (shown in Table 4-14) indicate that the elemental concentrations compare closely for Plants A, B, and C.

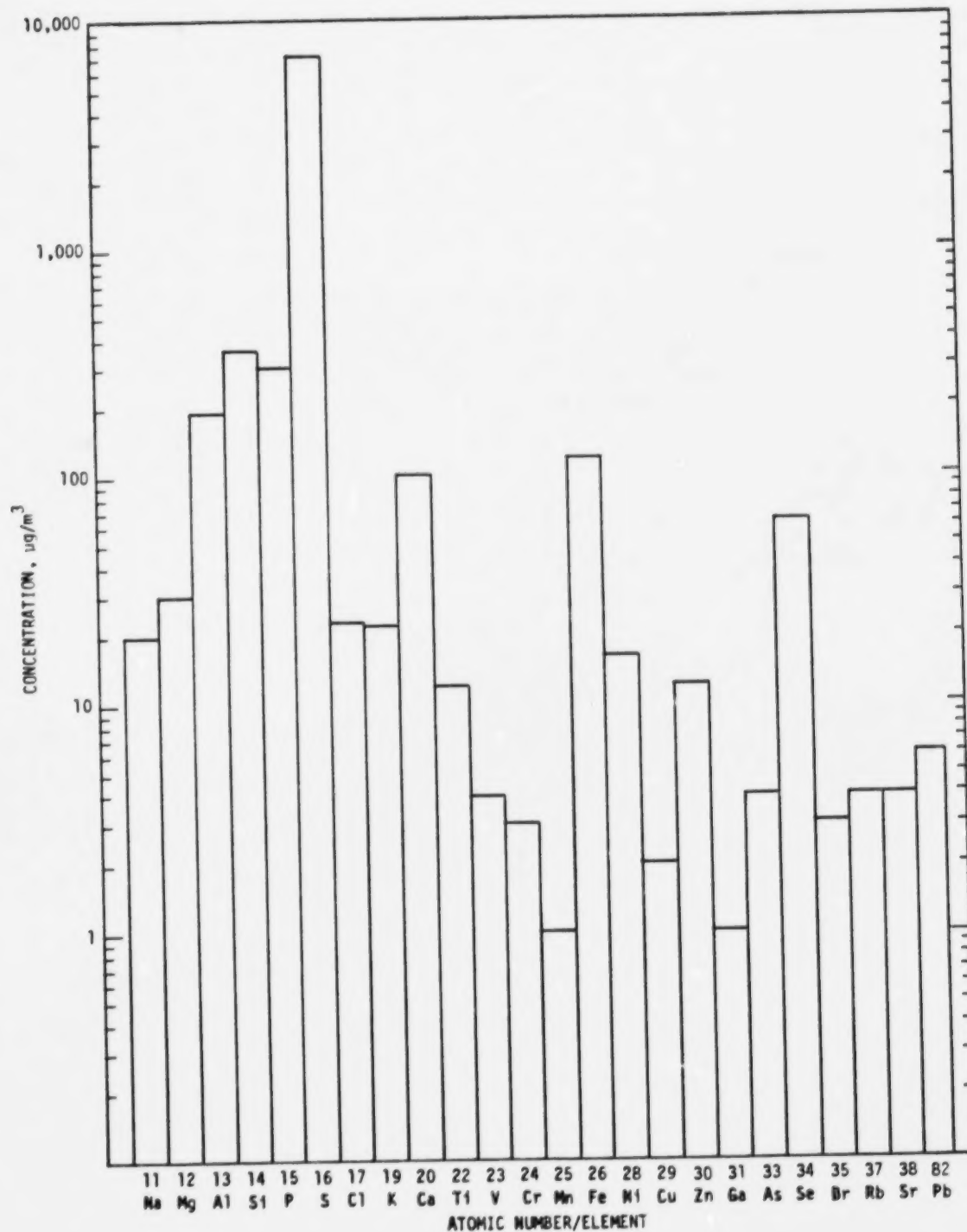


Figure 4-10. Plant D maximum elemental concentration measured.

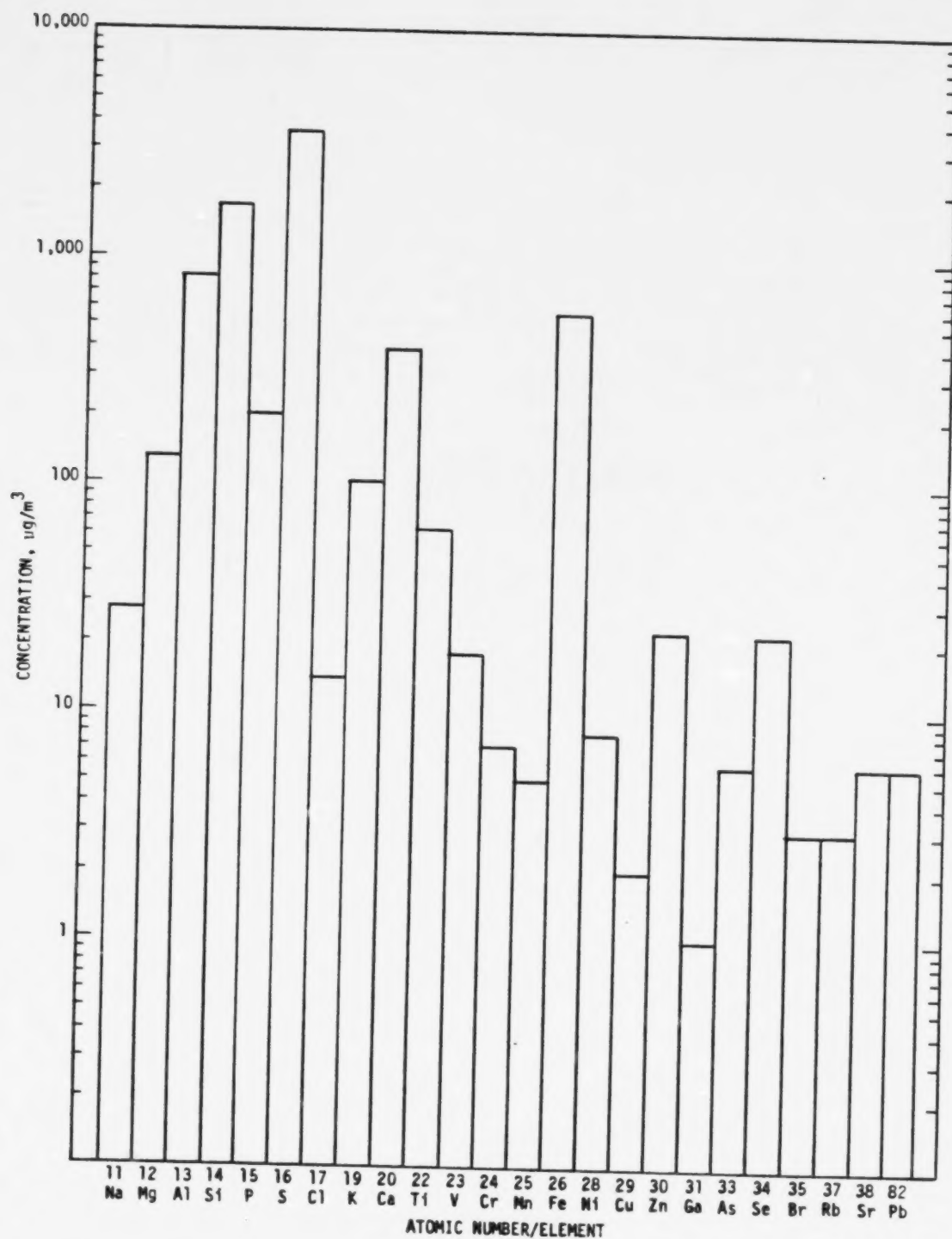


Figure 4-11. Plant E maximum elemental concentration measured.

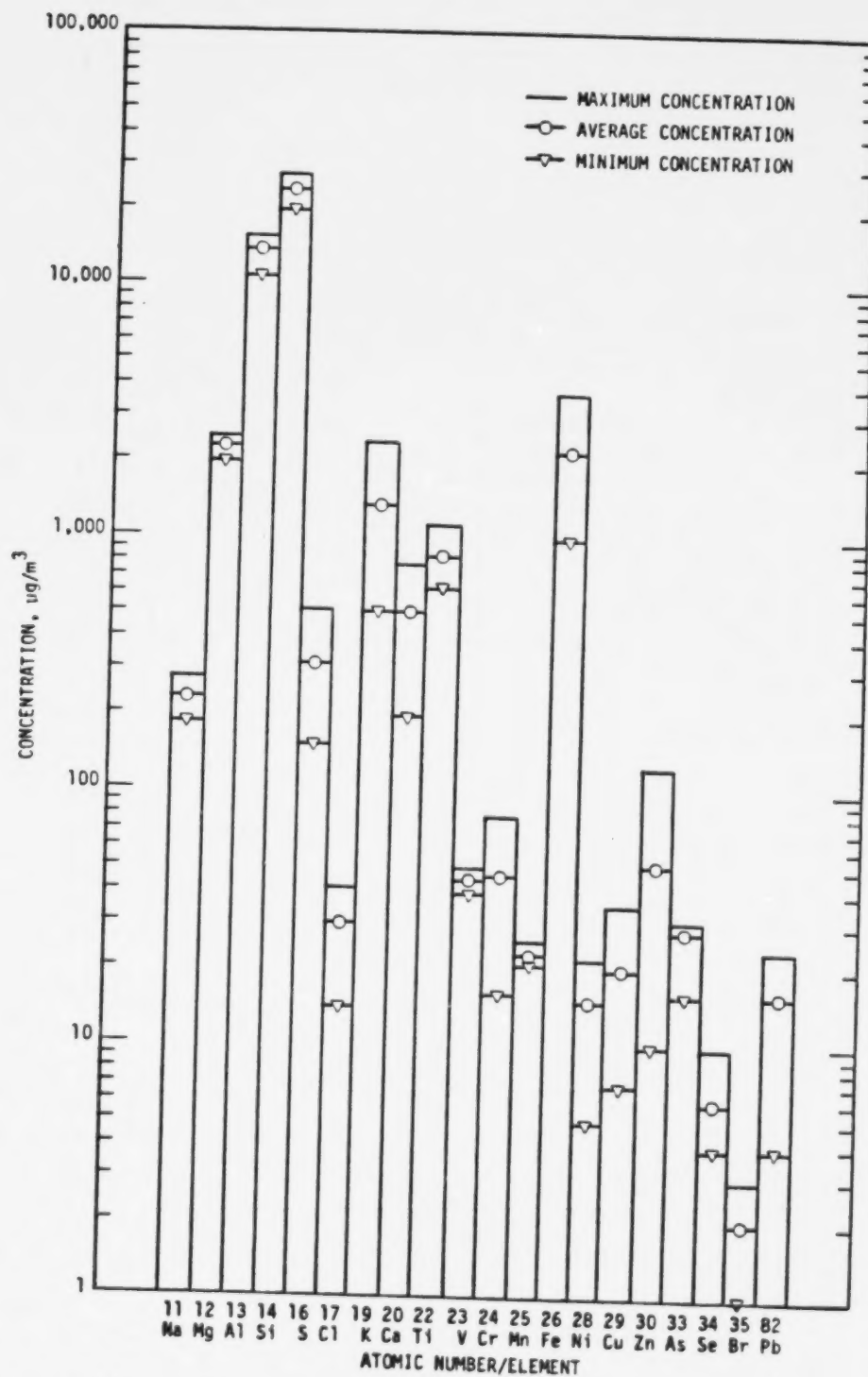


Figure 4-12. Plant A trace element concentrations for particles less than 9.7 μm .

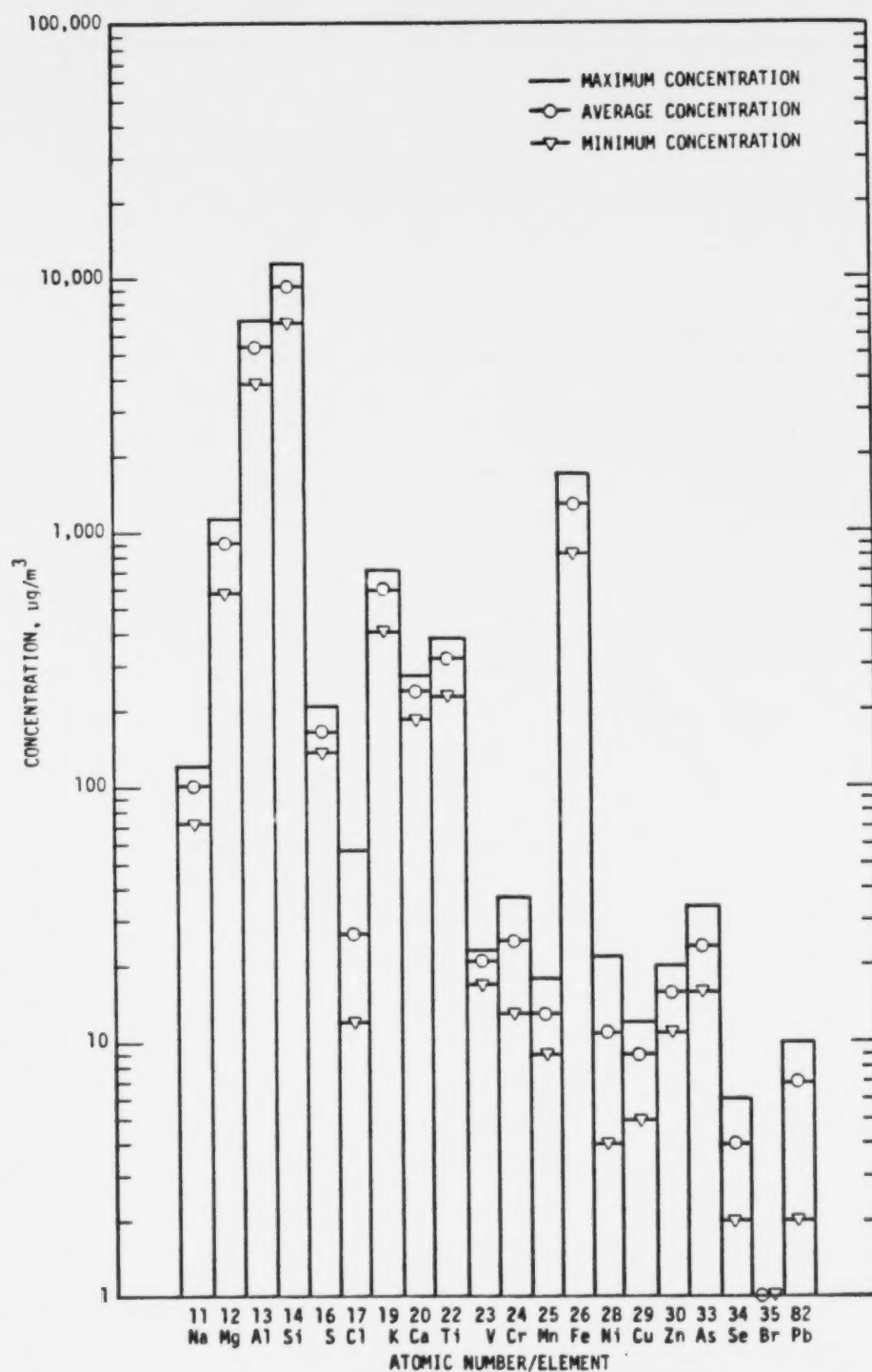


Figure 4-13. Plant A trace element concentrations for particles less than 4.0 μm .

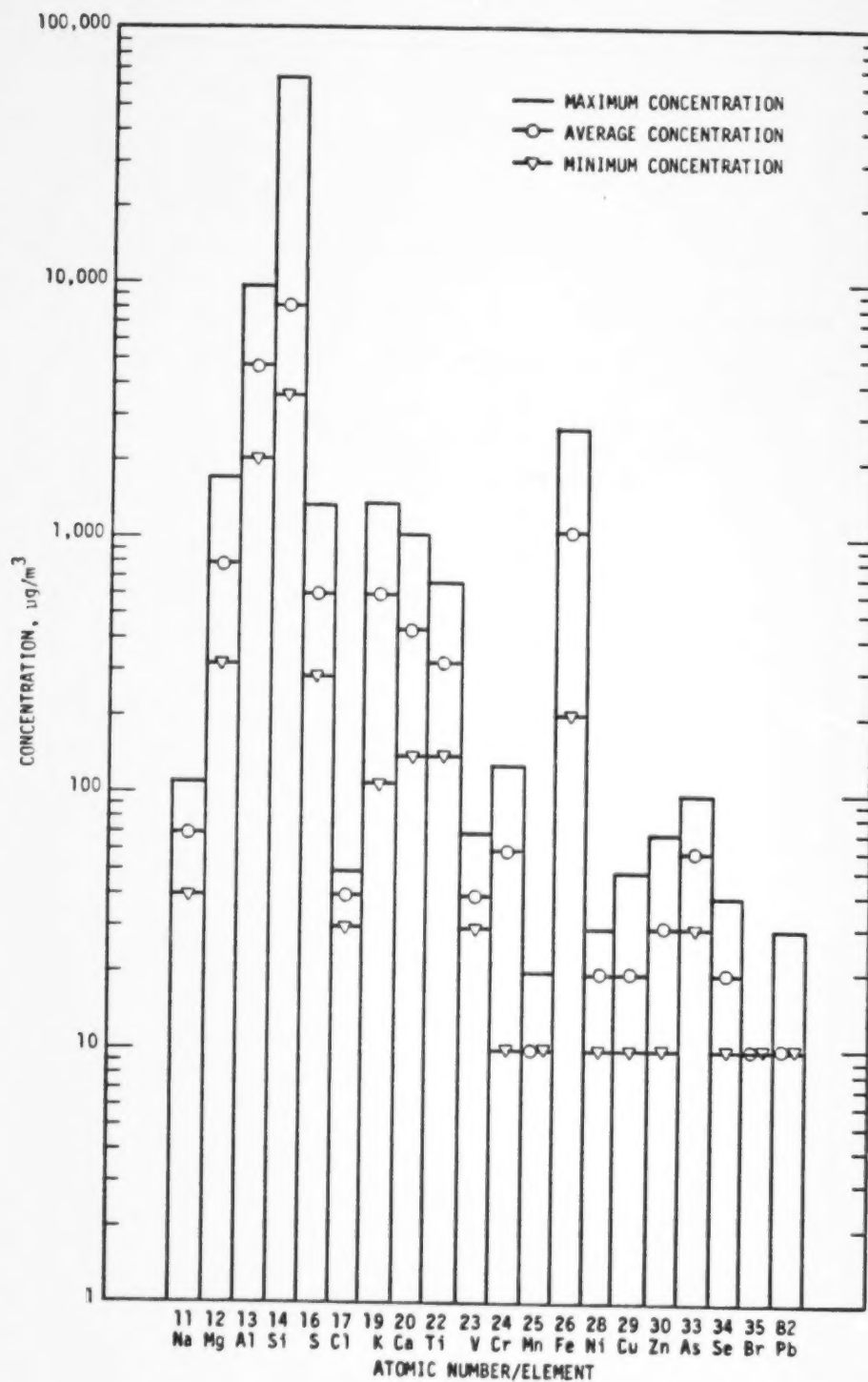


Figure 4-14. Plant A trace element concentrations for particles less than 1.1 μm .

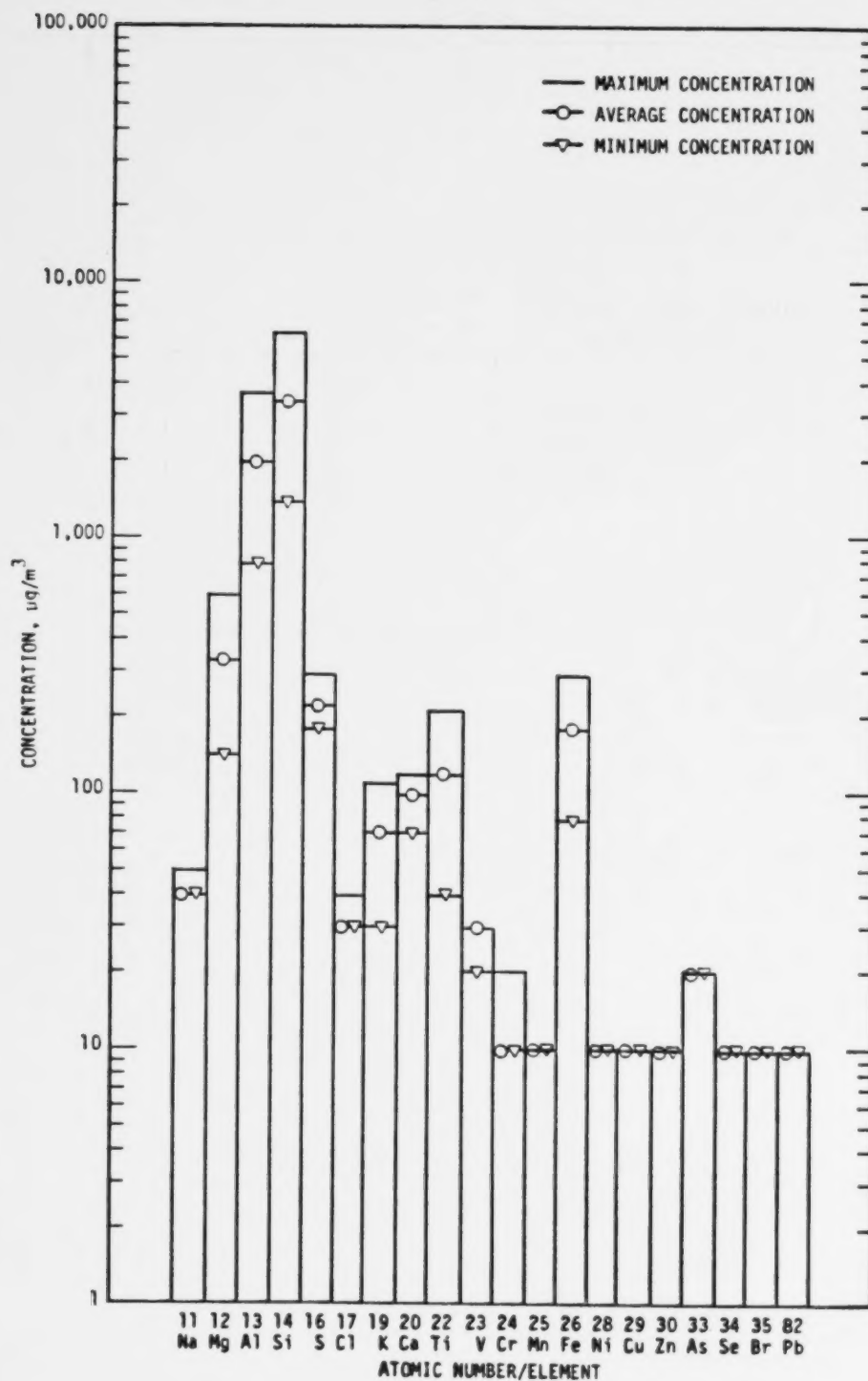


Figure 4-15. Plant A trace element concentrations for particles less than 0.36 μm .

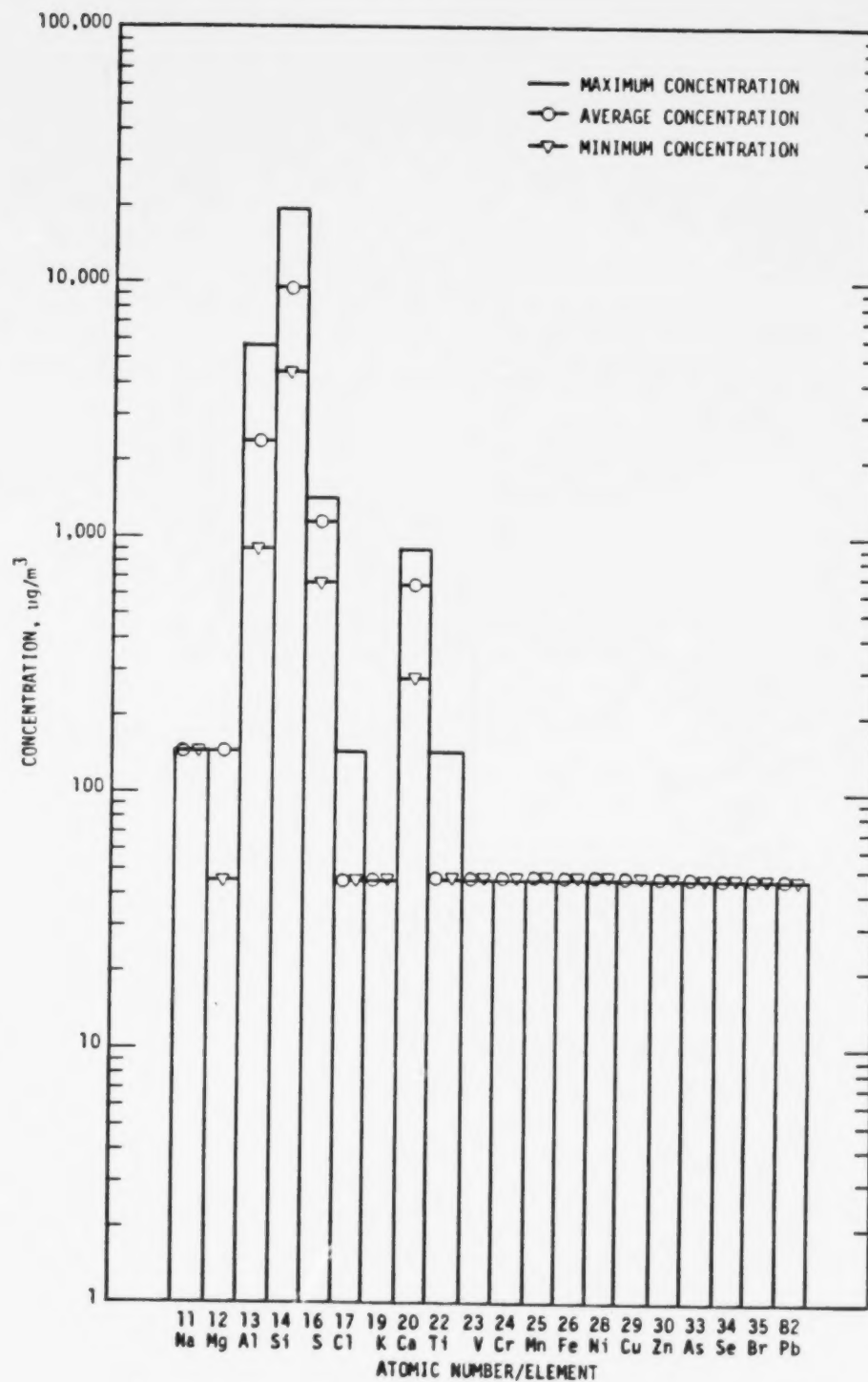


Figure 4-16. Plant B trace element concentrations for particles less than 8.5 μm .

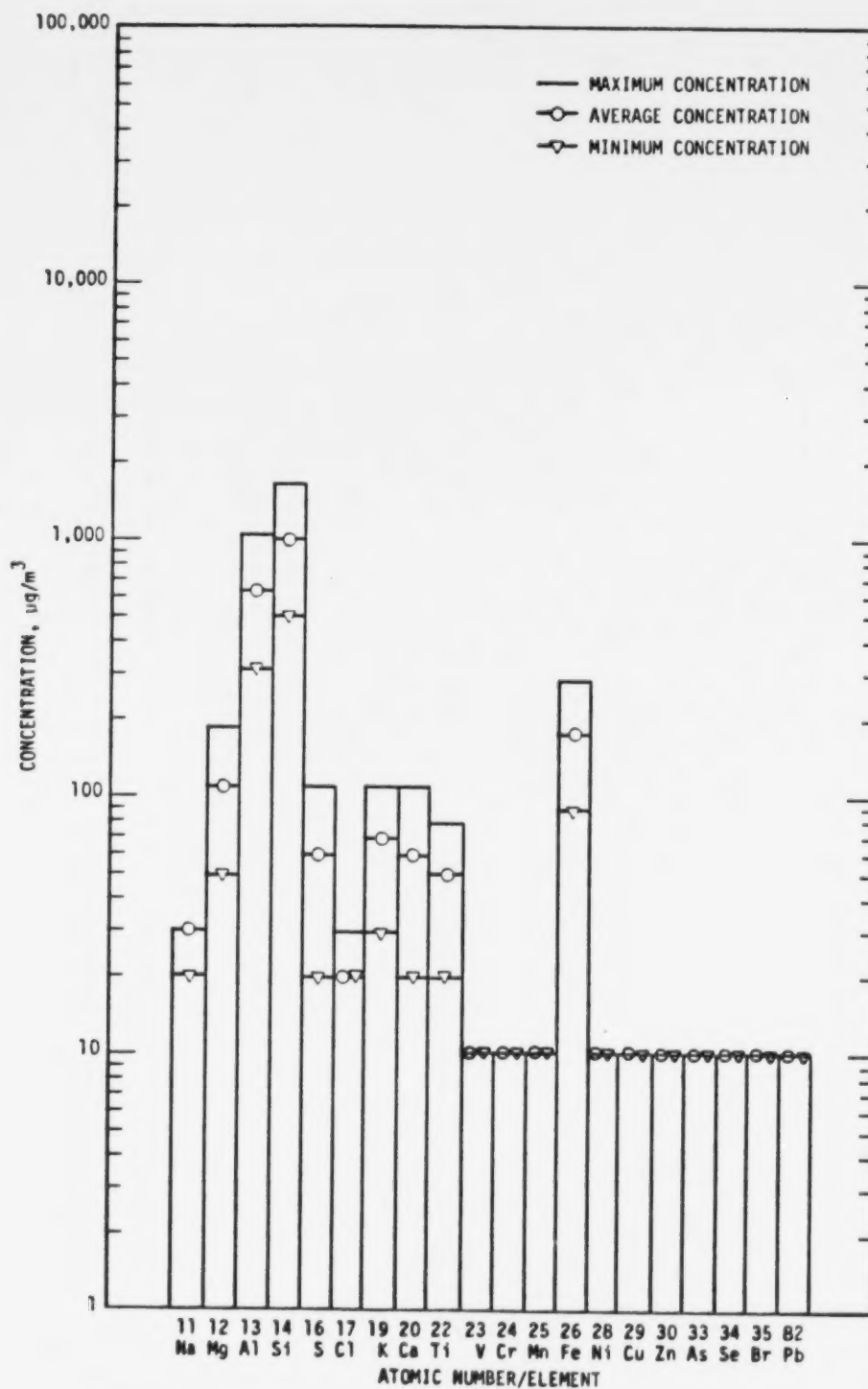


Figure 4-17. Plant B trace element concentrations for particles less than 3.8 μm .

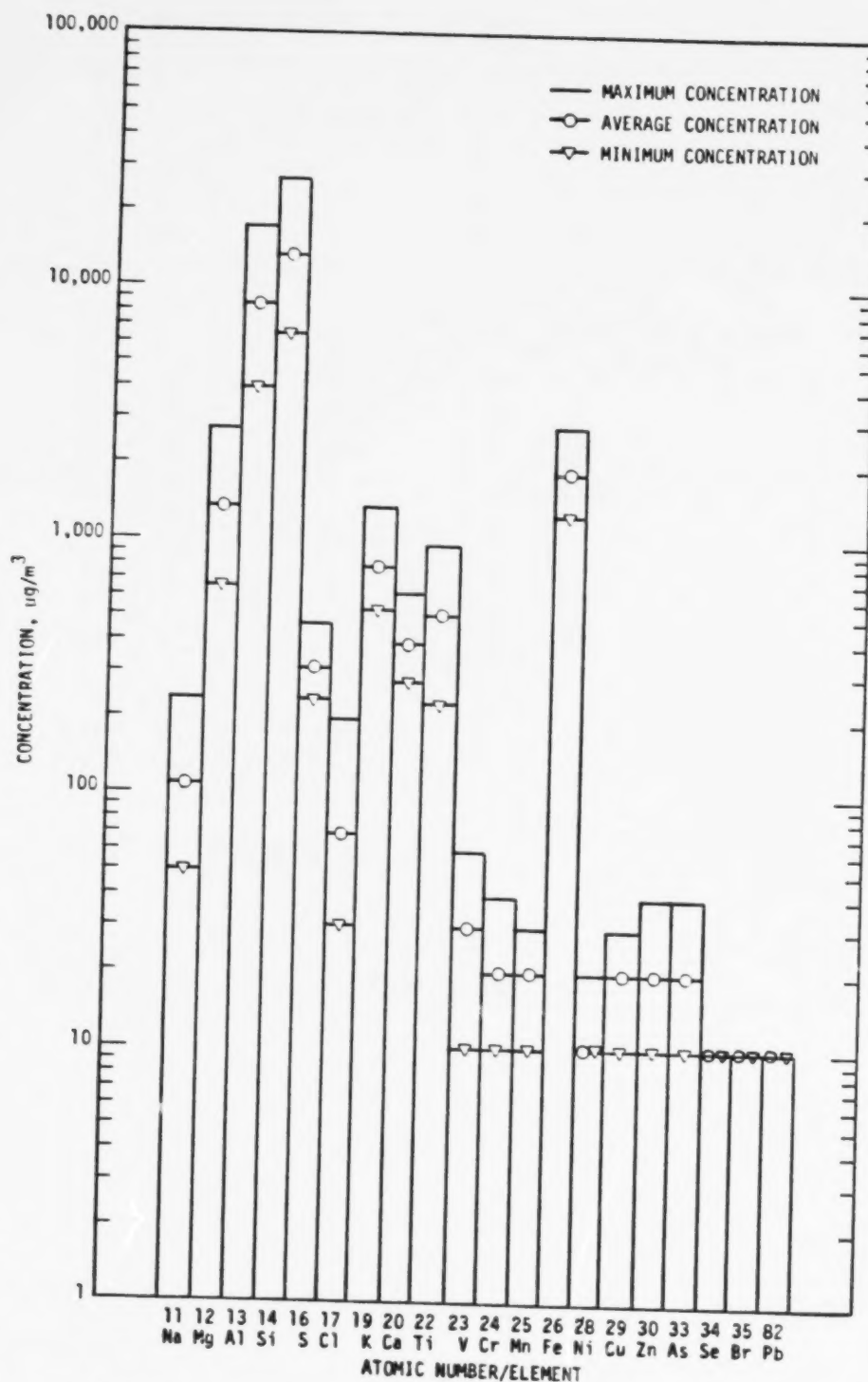


Figure 4-18. Plant B trace element concentrations for particles less than $0.93 \mu\text{m}$.

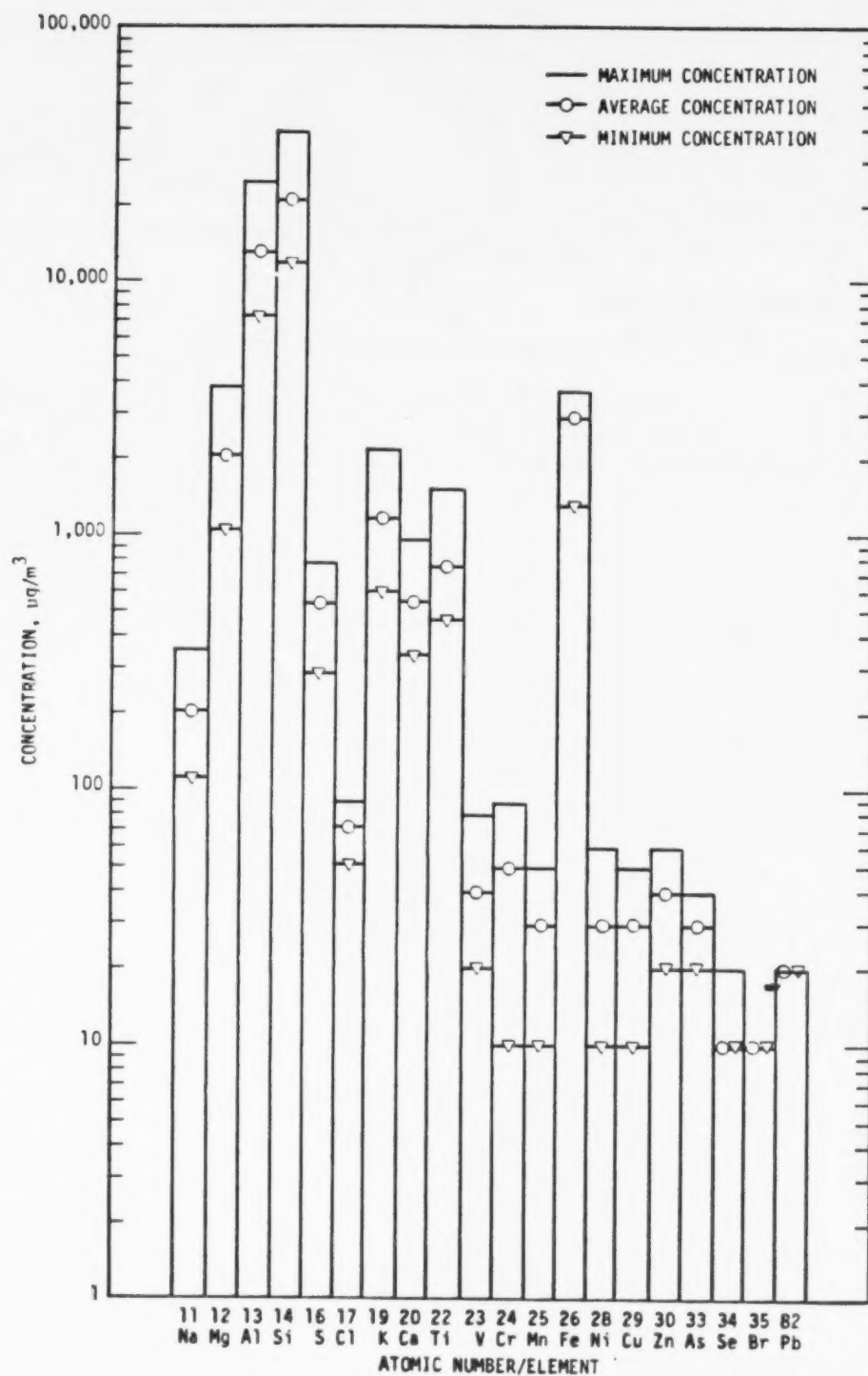


Figure 4-19. Plant B trace element concentrations for particles less than 0.29 μm.

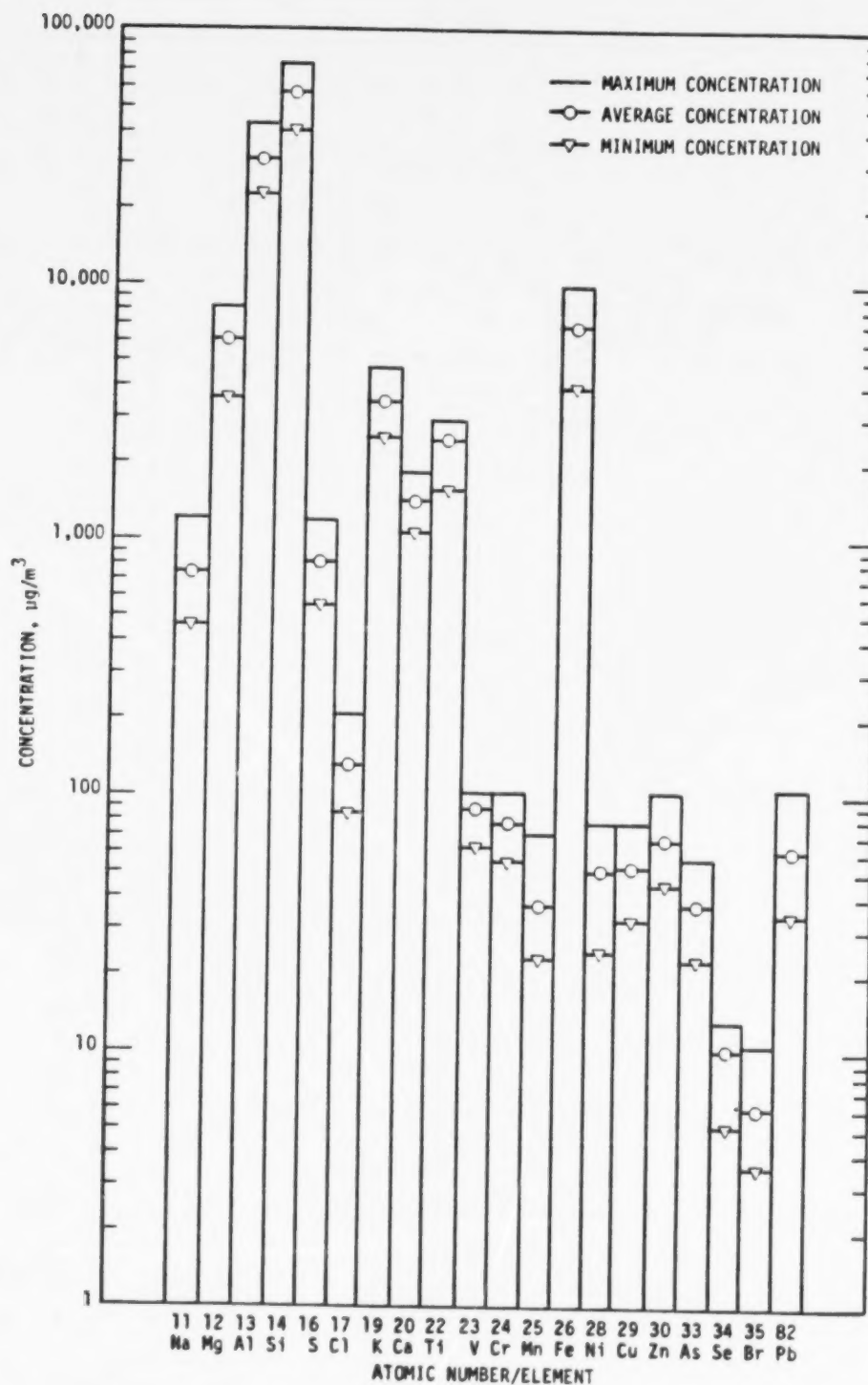


Figure 4-20. Plant C trace element concentrations for particles less than 9.8 μm .

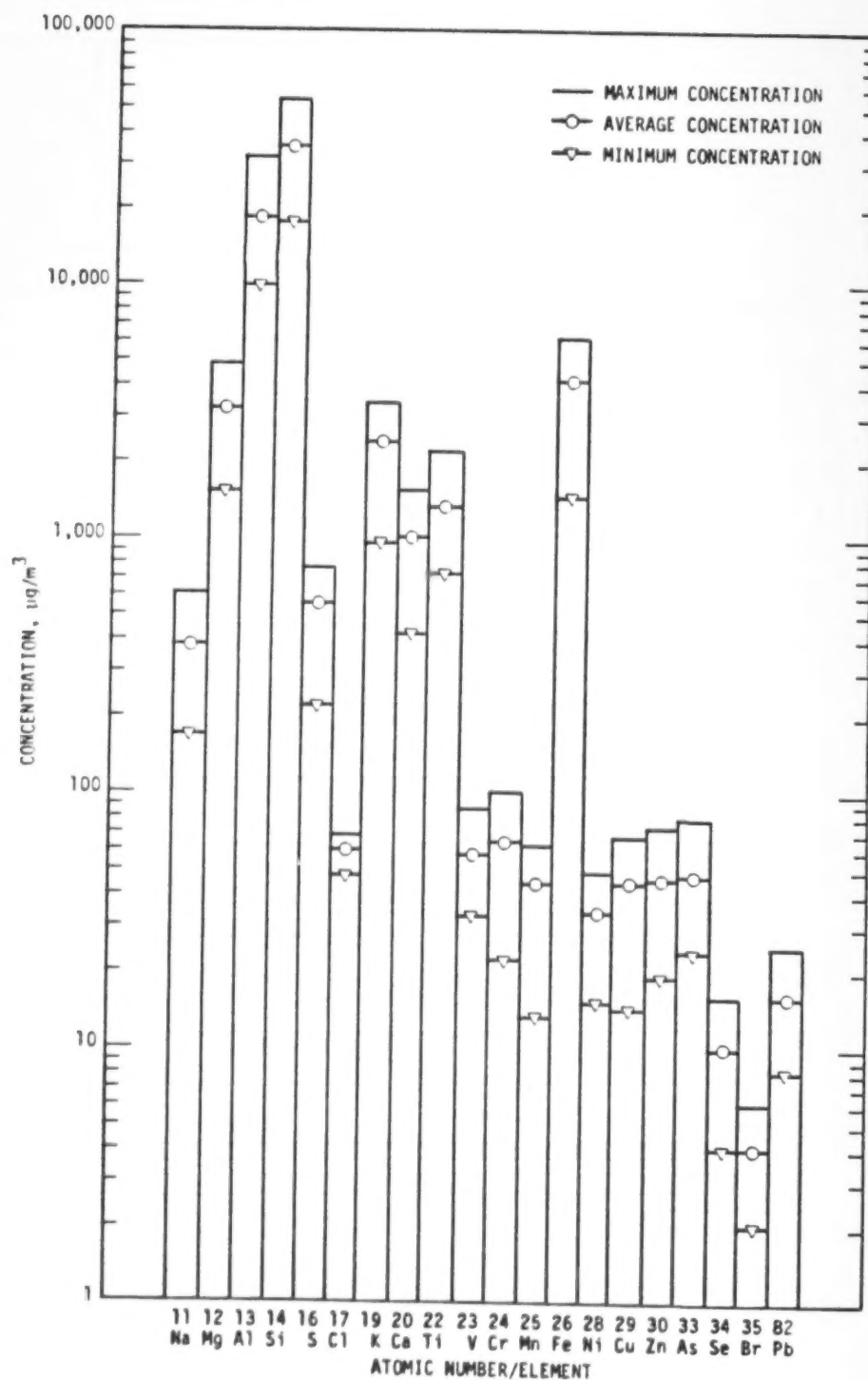


Figure 4-21. Plant C trace element concentrations for particles less than 4.05 μm .

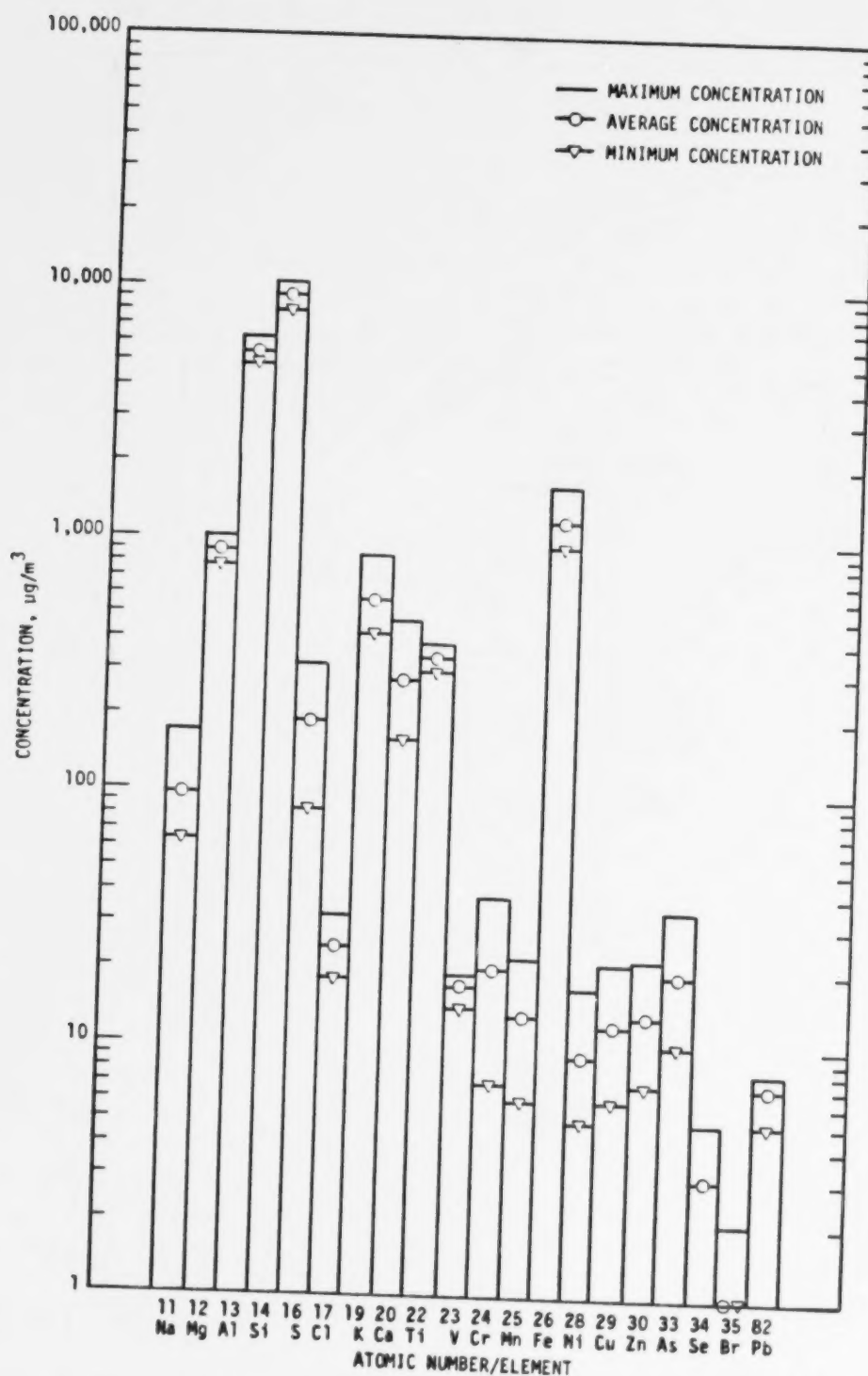


Figure 4-22. Plant C trace element concentrations for particles less than 1.1 μm .

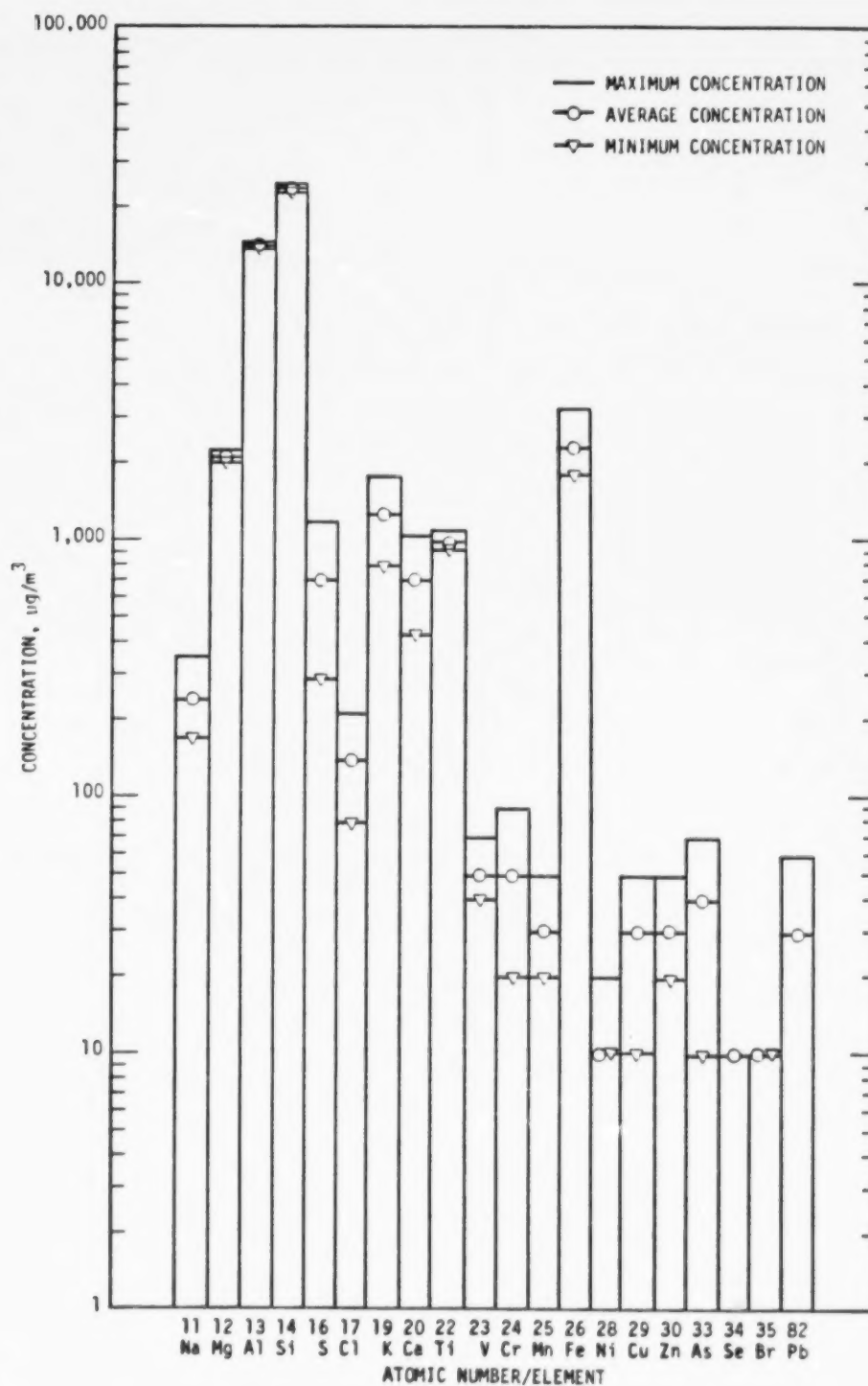


Figure 4-23. Plant C trace element concentrations for particles less than 0.38 μm .

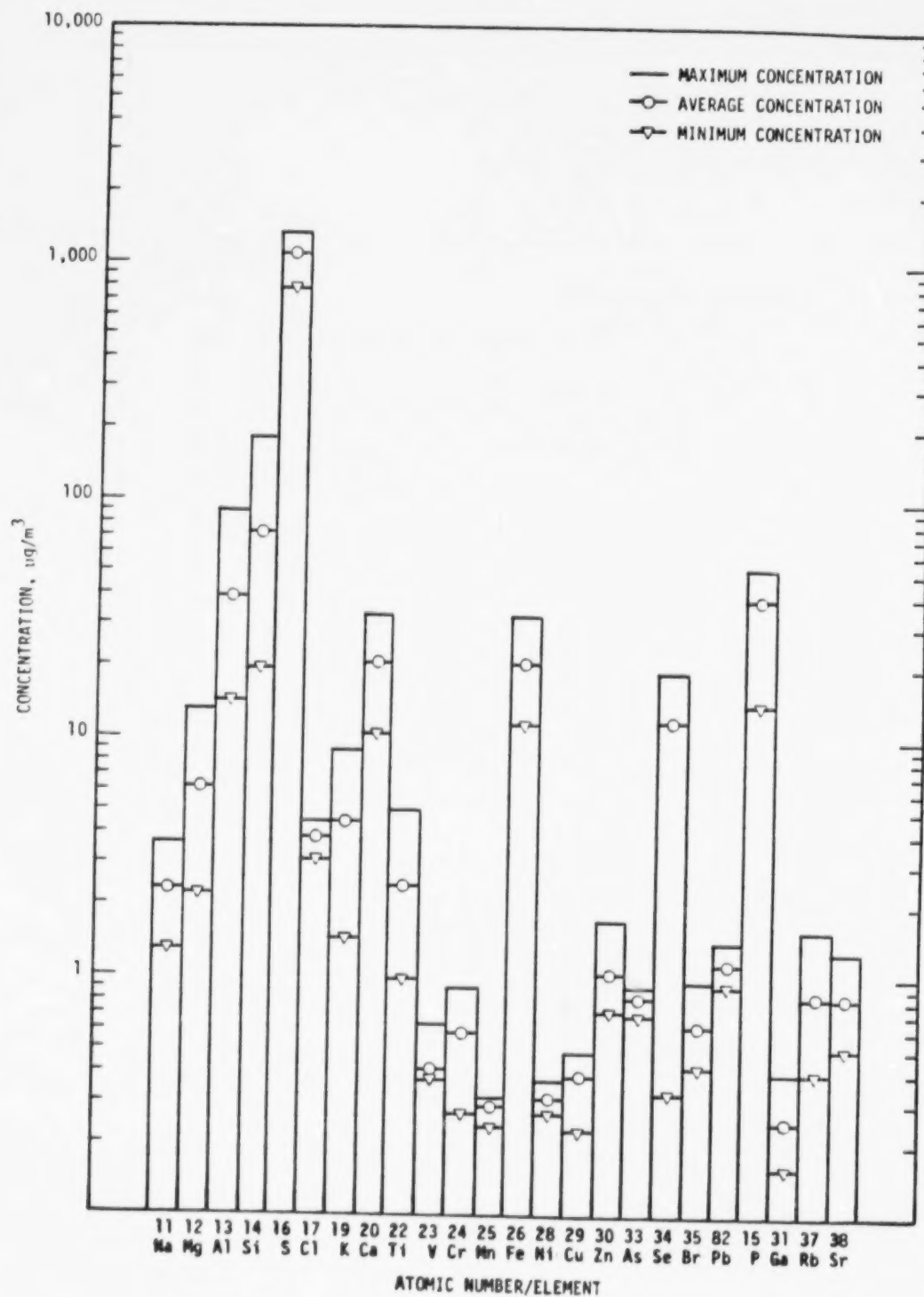


Figure 4-24. Plant D trace element concentrations for particles less than 8.3 μm .

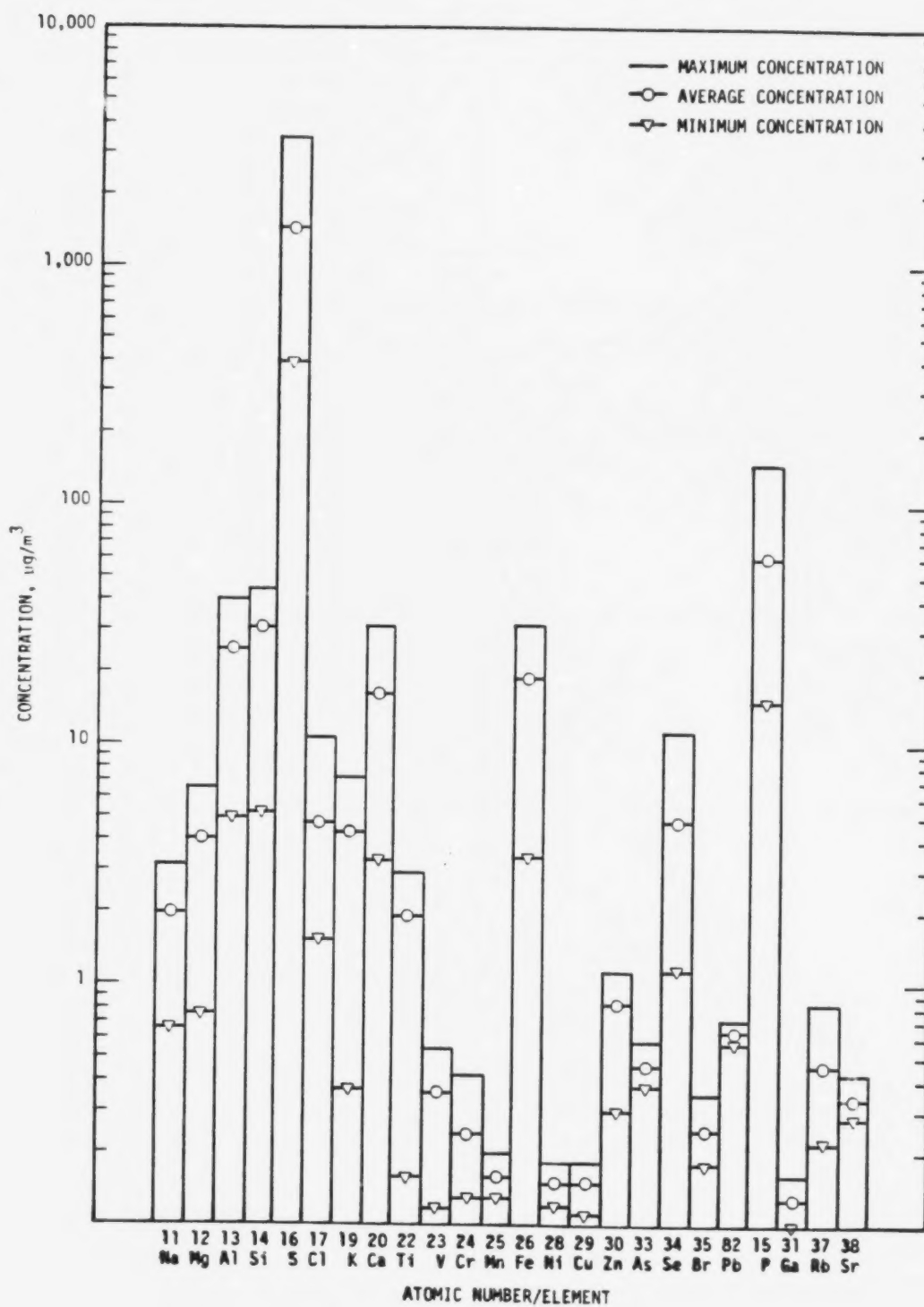


Figure 4-25. Plant D trace element concentrations for particles less than 3.4 μm .

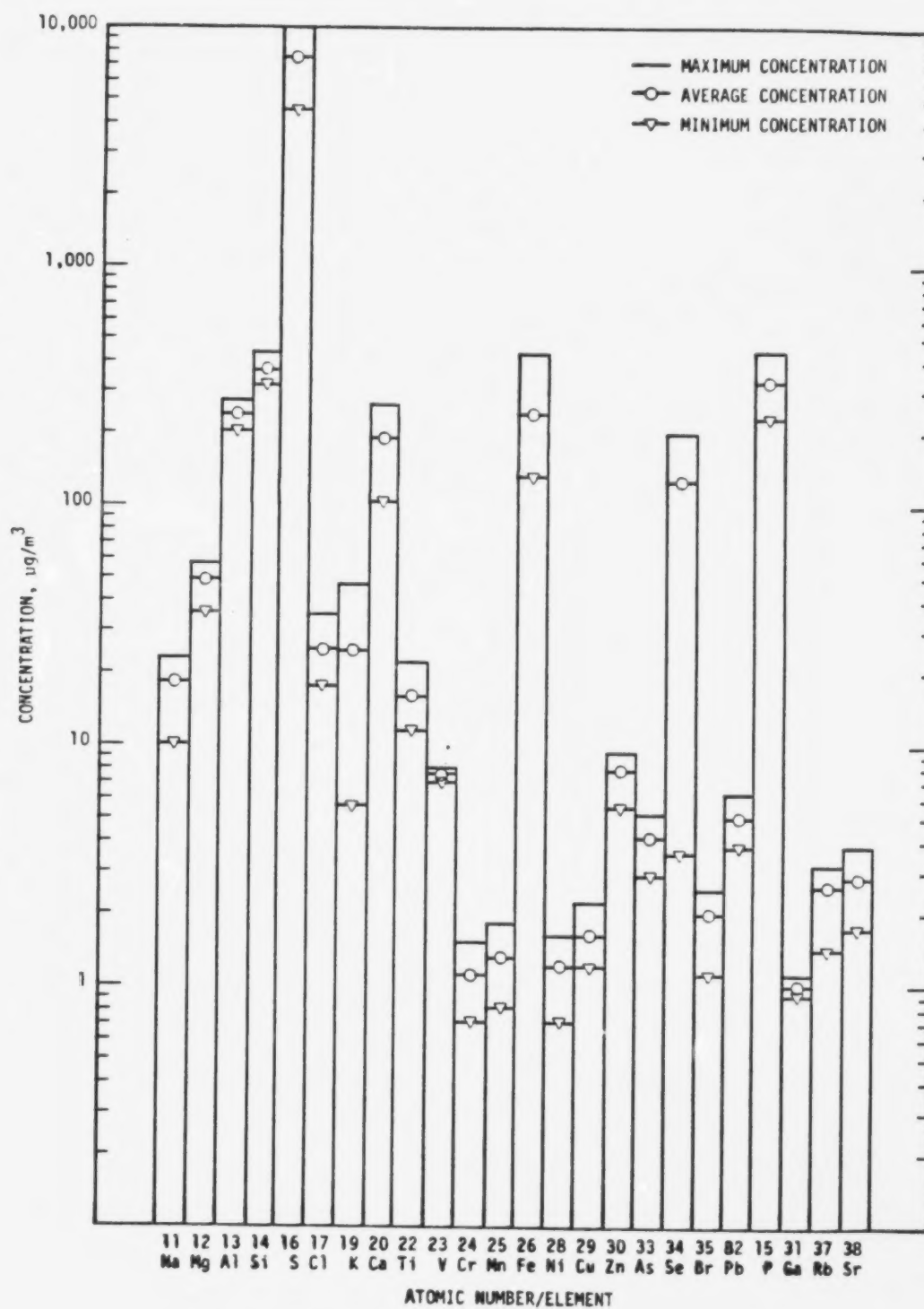


Figure 4-26. Plant D trace element concentrations for particles less than 0.92 μm .

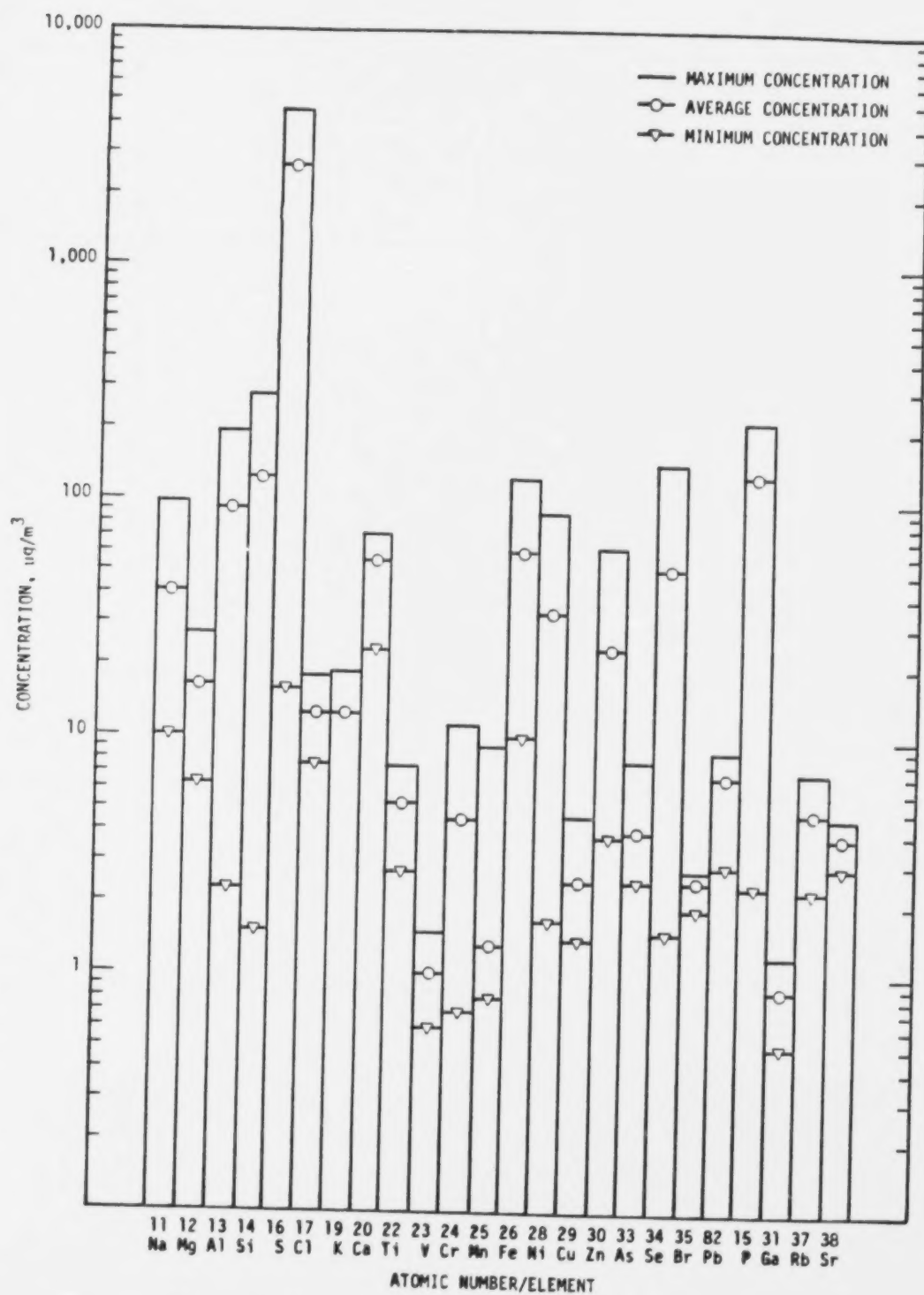


Figure 4-27. Plant D trace element concentrations for particles less than $0.30 \mu\text{m}$.

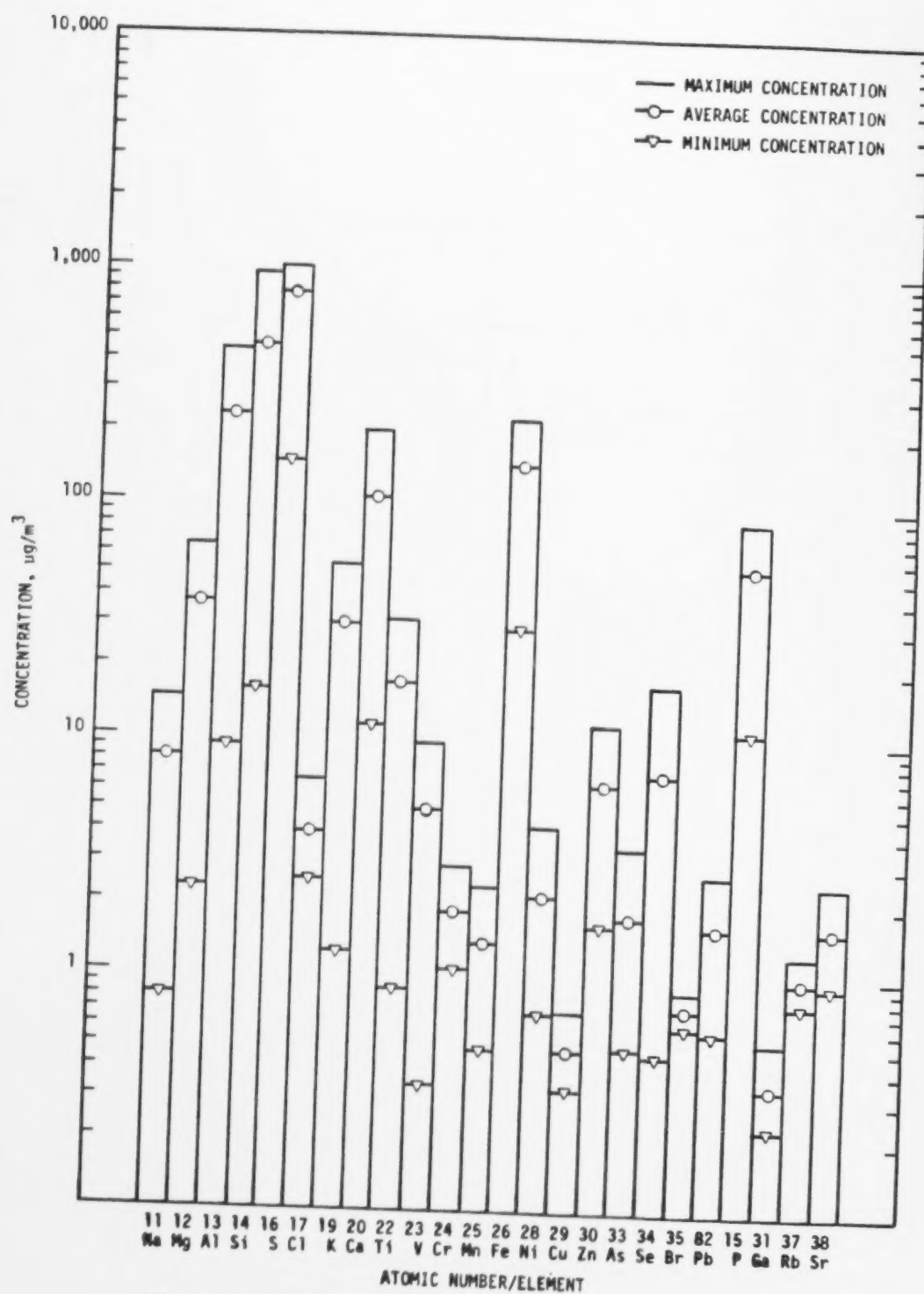


Figure 4-28. Plant E trace element concentrations for particles less than $8.9 \mu\text{m}$.

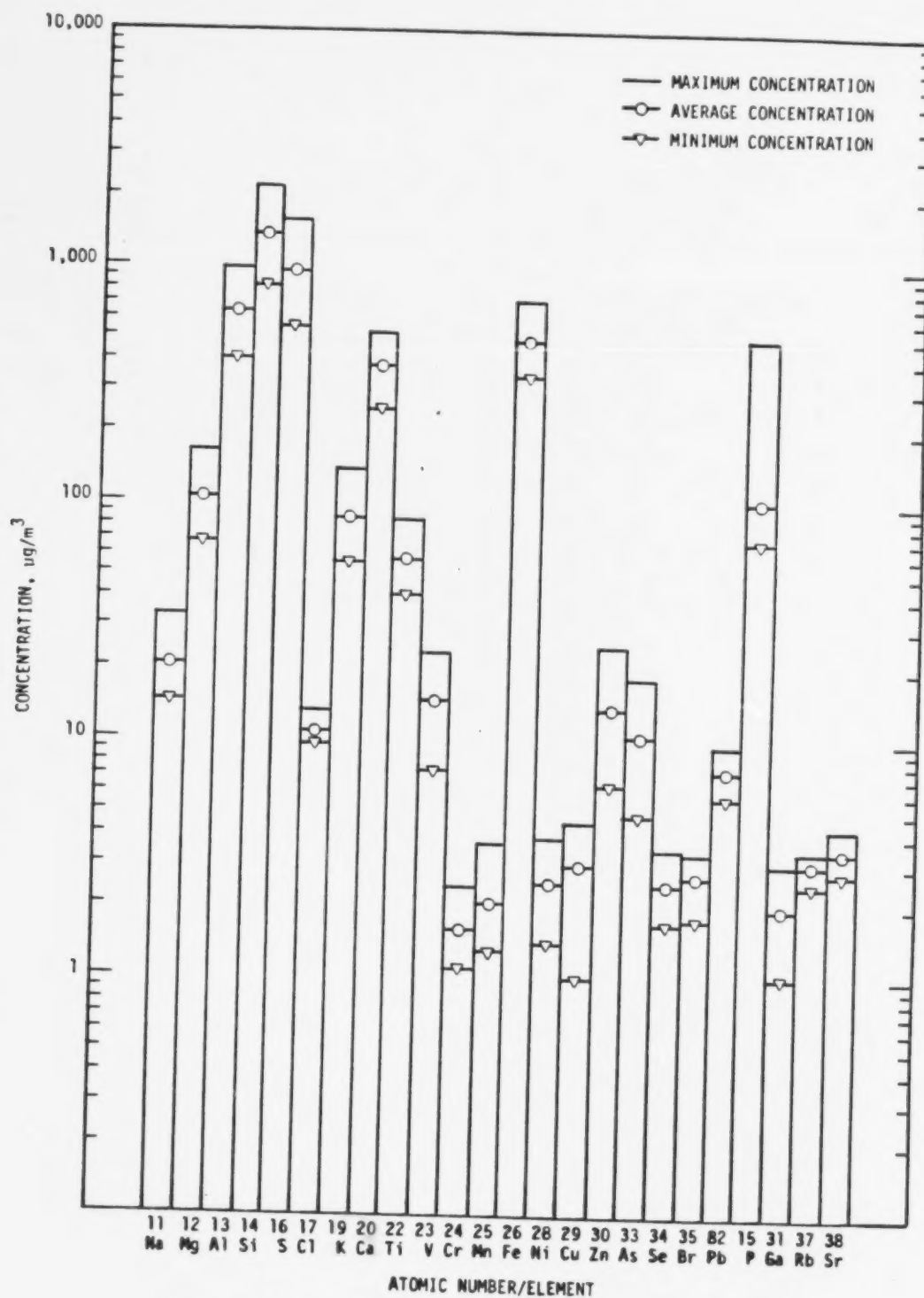


Figure 4-29. Plant E trace element concentrations for particles less than 3.6 μm .

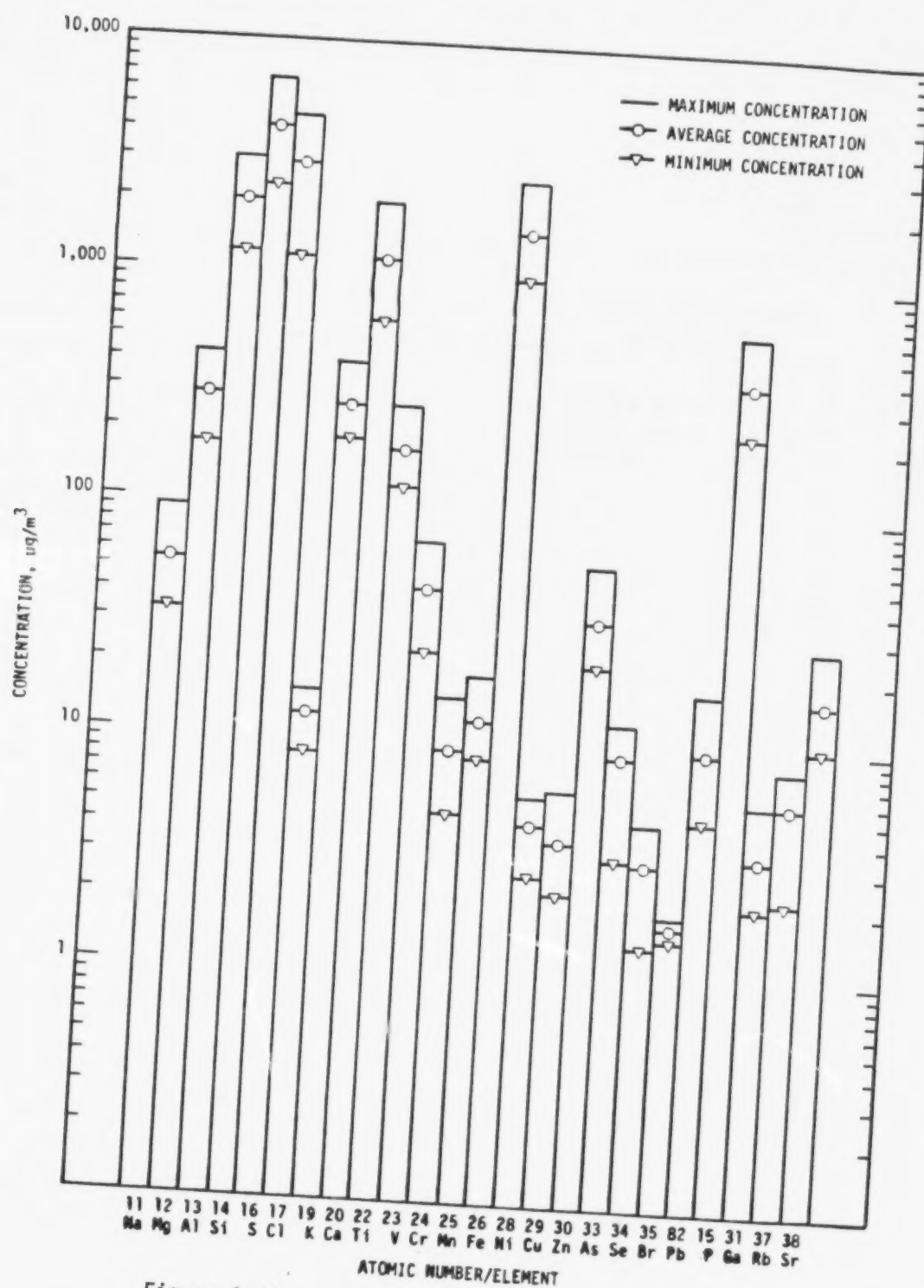


Figure 4-30. Plant E trace element concentrations for particles less than $0.98 \mu\text{m}$.

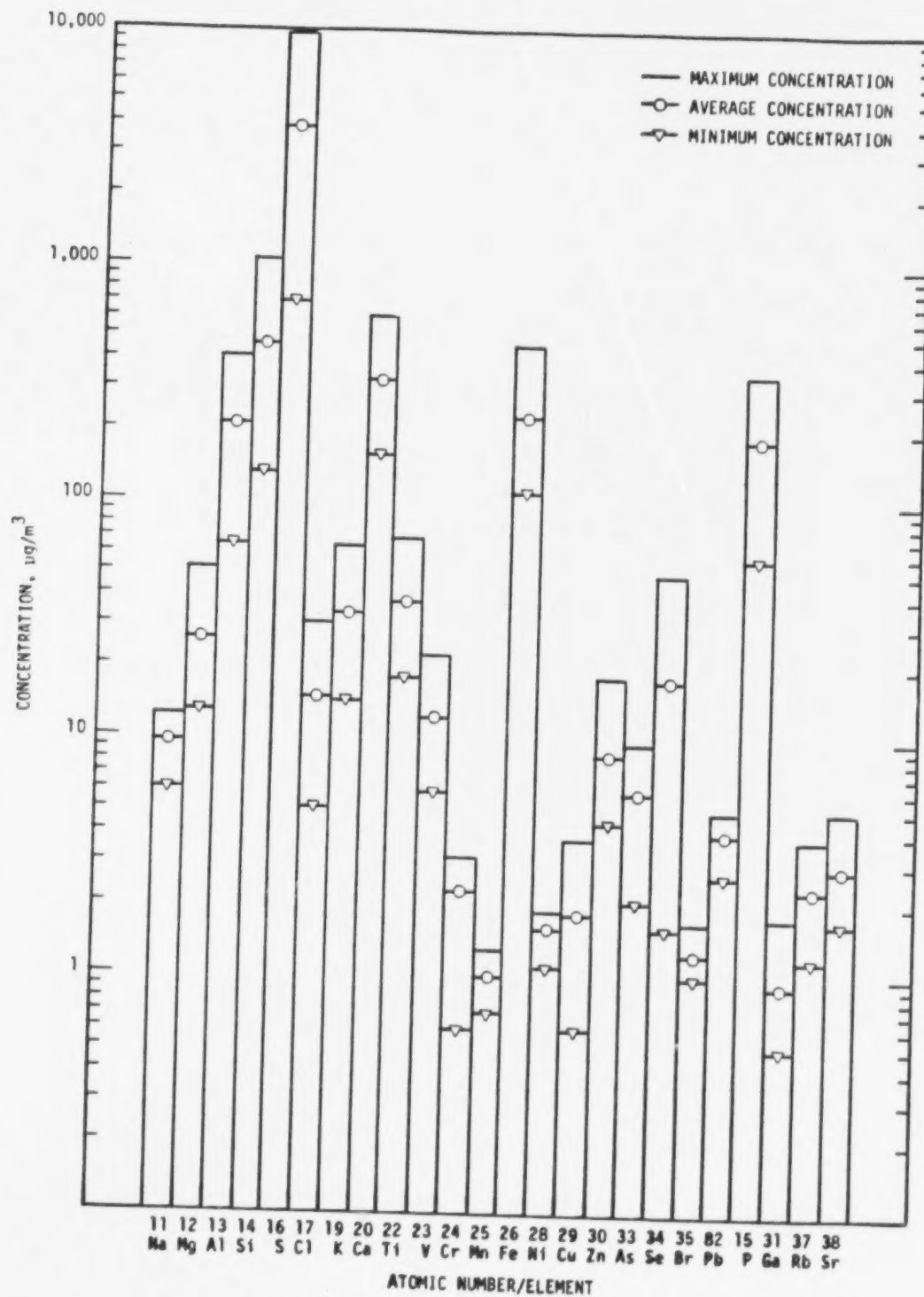


Figure 4-31. Plant E trace element concentrations for particles less than 0.32 μm .

TABLE 4-14. NORMALIZATION OF ELEMENTAL CONCENTRATIONS TO Si FOR PLANTS A, B, AND C

Element	<0.9.5 μm			<~ 4.0 μm			<1.0 μm			<0.40 μm		
	Plant A	Plant B	Plant C	Plant A	Plant B	Plant C	Plant A	Plant B	Plant C	Plant A	Plant B	Plant C
Na	0.010	0.009	0.013	0.011	0.008	0.011	0.009	<0.015	0.011	0.012	<0.071	0.010
Mg	0.095	0.095	0.108	0.097	0.109	0.091	0.097	0.103	0.097	0.096	0.071	0.086
Al	0.579	0.618	0.573	0.584	0.633	0.526	0.588	0.603	0.607	0.576	0.464	0.588
S	0.013	0.021	0.014	0.018	0.022	0.015	0.074	0.052	0.021	0.064	0.250	0.029
Cl	0.001	0.003	0.002	<0.003	<0.003	<0.002	<0.005	<0.015	<0.003	<0.009	<0.071	<0.006
K	0.056	0.053	0.061	0.063	0.052	0.067	0.074	0.059	0.064	0.020	0.036	0.052
Ca	0.021	0.026	0.025	0.026	0.025	0.029	0.054	0.052	0.031	0.029	0.179	0.029
Ti	0.036	0.039	0.042	0.034	0.038	0.037	0.040	0.037	0.037	0.064	0.036	0.041
V	0.002	0.002	0.002	0.002	0.002	0.002	0.005	<0.007	0.002	0.009	<0.036	0.002
Cr	0.002	0.001	0.001	0.003	0.002	0.002	0.007	0.015	0.002	0.003	<0.036	0.002
Mn	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.007	0.001	<0.003	<0.036	0.001
Fe	0.096	0.129	0.123	0.139	0.122	0.0120	0.132	0.206	0.132	0.052	0.357	0.097
Ni	0.001	0.001	0.001	0.001	0.001	0.001	0.002	<0.007	0.001	<0.003	<0.036	-
Cu	0.001	0.001	0.001	0.001	0.001	0.001	0.002	<0.007	0.001	<0.003	<0.036	0.001
Zn	0.002	0.002	0.001	0.002	0.001	0.001	0.004	<0.007	0.001	<0.003	<0.036	0.001
As	0.001	0.001	0.001	0.003	0.001	0.001	0.007	<0.007	0.002	0.006	<0.036	0.002
Se	-	0.001	-	-	<0.001	-	0.002	<0.007	-	<0.003	<0.036	-
Br	-	<0.001	-	-	<0.001	-	<0.001	<0.007	-	<0.003	<0.036	-
Pb	0.001	0.001	0.001	0.001	<0.001	-	0.001	<0.007	<0.001	<0.003	<0.036	0.001

Tables 4-15 through 4-19 summarize the emission factor and mass emission rate for each trace element detected. These data are based on Method 5 particulate concentrations since this data is considered to represent the filterable particulate emissions.

TABLE 4-15. GROUP I AVERAGE TRACE ELEMENT EMISSION RATES AND FACTORS
FOR THE FOUR SIZE RANGES SAMPLED

Element	Elemental emission factor, mg/MJ				Elemental emission rate, kg/h			
	Plant B				Plant B			
	<8.5 μm	<3.8 μm	<0.93 μm	<0.29 μm	<8.5 μm	<3.8 μm	<0.93 μm	<0.29 μm
Na	0.022	0.012	0.004	0.002	0.012	0.006	0.002	0.002
Mg	0.234	0.158	0.012	0.002	0.126	0.086	0.006	0.002
Al	1.49	0.970	0.072	0.012	0.803	0.527	0.038	0.008
Si	2.444	1.547	0.118	1.028	1.312	0.841	0.062	0.018
S	0.062	0.036	0.006	0.008	0.032	0.020	0.004	0.004
Cl	0.008	0.008	0.002	0.002	0.004	0.004	0.002	-
K	0.134	0.090	0.080	0.002	0.072	0.048	0.004	-
Ca	0.062	0.046	0.006	0.002	0.038	0.024	0.004	0.006
Ti	0.086	0.058	0.006	0.002	0.046	0.032	0.004	-
V	0.004	0.004	0.002	0.002	0.002	0.002	-	-
Cr	0.006	0.002	0.002	0.002	0.002	-	-	-
Mn	0.004	0.004	0.002	0.002	-	-	-	-
Fe	0.337	0.210	0.220	0.008	0.160	0.114	0.010	0.004
Ni	0.004	0.002	0.002	0.002	0.002	-	-	-
Cu	0.004	0.002	0.002	0.002	0.002	-	-	-
Zn	0.004	0.002	0.002	0.002	0.002	0.002	-	-
As	0.004	0.002	0.002	0.002	0.002	-	-	-
Se	0.002	0.002	0.002	0.002	-	-	-	-
Br	0.002	0.002	0.002	0.002	-	-	-	-
Pb	0.002	0.002	0.002	0.002	0.002	-	-	-

TABLE 4-16. GROUP II AVERAGE TRACE ELEMENT EMISSION RATES AND FACTORS
FOR THE FOUR SIZE RANGES SAMPLED

Element	Elemental emission factor, mg/MJ				Elemental emission rate, kg/h			
	Plant C				Plant C			
	<9.8 μm	<4.1 μm	<1.1 μm	<0.38 μm	<9.8 μm	<4.1 μm	<1.1 μm	<0.38 μm
Na	0.581	0.302	0.073	0.018	0.536	0.279	0.072	0.018
Mg	4.886	2.579	0.064	0.157	4.509	2.380	0.663	0.156
Al	25.950	14.854	4.213	1.067	23.950	13.710	4.137	1.063
Si	45.301	28.242	6.943	1.815	41.810	26.065	6.818	1.808
S	0.641	0.509	0.144	0.052	0.591	0.382	0.142	0.052
Cl	0.100	0.046	0.018	0.010	0.093	0.043	0.018	0.010
K	2.761	1.876	0.444	0.095	2.548	1.732	0.436	0.094
Ca	1.110	0.808	0.212	0.052	1.025	0.746	0.208	0.052
Ti	1.914	1.150	0.259	0.092	1.766	0.972	0.254	0.074
V	0.068	0.044	0.013	0.004	0.063	0.041	0.013	0.004
Cr	0.061	0.050	0.015	0.004	0.056	0.046	0.015	0.004
Mn	0.029	0.034	0.010	0.002	0.027	0.032	0.010	0.002
Fe	5.591	3.376	0.918	0.175	5.160	3.116	0.901	0.175
Ni	0.039	0.029	0.007	0.001	0.036	3.141	0.007	0.001
Cu	0.041	0.035	0.009	0.003	0.037	0.033	0.009	0.002
Zn	0.052	0.036	0.010	0.003	0.048	0.033	0.010	0.003
As	0.029	0.038	0.014	0.004	0.027	0.035	0.014	0.003
Se	0.008	0.008	0.002	0.001	0.007	0.007	0.002	0.001
Br	0.005	0.003	0.001	0.001	0.004	0.003	0.001	0.001
Pb	0.047	0.013	0.006	0.004	0.044	0.012	0.005	0.003

TABLE 4-17. GROUP II AVERAGE TRACE ELEMENT EMISSION RATES AND FACTORS
FOR THE FOUR SIZE RANGES SAMPLED

Element	Elemental emission factor, mg/MJ				Elemental emission rate, kg/h			
	Plant E				Plant E			
	<8.9 μm	<3.6 μm	<0.98 μm	<0.32 μm	<8.9 μm	<3.6 μm	<0.98 μm	<0.32 μm
Na	0.011	0.003	0.007	0.001	0.021	0.005	0.014	0.002
Mg	0.049	0.014	0.039	0.004	0.098	0.027	0.072	0.006
Al	0.315	0.086	0.275	0.029	0.631	0.166	0.509	0.053
Si	0.629	0.182	0.573	0.062	1.261	0.351	1.061	0.115
P	0.076	0.014	0.053	0.026	0.152	0.028	0.098	0.047
S	1.335	0.128	0.409	0.521	2.673	0.247	0.759	0.959
Cl	0.005	0.001	0.002	0.002	0.010	0.003	0.003	0.004
K	0.040	0.012	0.037	0.005	0.080	0.022	0.068	0.008
Ca	0.143	0.051	0.153	0.044	0.286	0.098	0.282	0.081
Ti	0.023	0.008	0.024	0.005	0.047	0.015	0.045	0.009
V	0.007	0.002	0.005	0.002	0.013	0.004	0.010	0.003
Cr	0.002	-	0.001	-	0.005	-	0.002	0.001
Mn	0.002	-	0.002	-	0.004	0.001	0.003	-
Fe	0.196	0.068	0.220	0.032	0.393	0.130	0.407	0.058
Ni	0.003	-	0.001	-	0.006	0.001	0.001	-
Cu	0.001	-	0.001	-	0.001	0.001	0.001	-
Zn	0.009	0.002	0.005	0.001	0.017	0.004	0.009	0.002
Ga	-	-	0.001	-	0.001	0.001	0.001	-
As	0.002	0.001	0.001	0.001	0.005	0.003	0.002	0.001
Se	0.008	-	-	0.002	0.016	0.001	0.001	0.004
Br	0.001	0.004	-	-	0.002	0.001	-	-
Pb	0.004	0.001	0.001	0.001	0.007	0.002	0.022	0.001
Rb	0.001	-	0.001	-	0.003	0.001	0.001	0.001
Sr	0.002	0.001	0.002	-	0.004	0.001	0.004	0.001

TABLE 4-18. GROUP III AVERAGE TRACE ELEMENT EMISSION RATES AND FACTORS
FOR THE FOUR SIZE RANGES SAMPLED

Element	Elemental emission factor, mg/MJ				Elemental emission rate, kg/h			
	Plant A				Plant A			
	<9.7 μm	<4.0 μm	<1.1 μm	<0.36 μm	<9.7 μm	<4.0 μm	<1.1 μm	<0.36 μm
Na	0.338	0.104	0.011	0.006	0.935	0.274	0.028	0.017
Mg	3.354	1.483	0.121	0.049	9.259	3.881	0.327	0.132
Al	20.493	8.936	0.739	0.295	56.571	23.385	2.005	0.788
Si	35.412	15.303	1.259	0.514	97.753	40.048	3.413	1.372
S	0.465	0.266	0.093	0.032	1.283	0.699	0.249	0.087
Cl	0.045	0.045	0.006	0.004	0.125	0.117	0.017	0.009
K	1.975	0.958	0.085	0.011	5.450	2.509	0.231	0.028
Ca	0.745	0.393	0.070	0.013	2.056	1.030	0.187	0.038
Ti	1.268	0.520	0.051	0.017	3.500	1.361	2.572	0.045
V	0.066	0.034	0.006	0.004	0.183	0.089	0.017	0.009
Cr	0.068	0.040	0.008	0.002	0.189	0.106	0.023	0.004
Mn	0.034	0.021	0.002	-	0.094	0.055	0.006	0.002
Fe	3.384	2.122	0.166	-	9.343	5.556	0.450	0.070
Ni	0.023	0.019	0.002	-	0.060	0.047	0.004	-
Cu	0.030	0.015	0.002	-	0.081	0.040	0.008	0.002
Zn	0.079	0.026	0.006	-	0.217	0.068	0.013	0.002
As	0.043	0.040	0.008	0.002	0.119	0.102	0.023	0.008
Se	0.009	0.006	0.002	-	0.026	0.017	0.008	0.002
Br	0.002	-	-	-	0.008	0.002	-	-
Pb	0.023	0.011	0.002	-	0.064	0.028	0.004	0.002

TABLE 4-19. GROUP III AVERAGE TRACE ELEMENT EMISSION RATES AND FACTORS
FOR THE FOUR SIZE RANGES SAMPLED

Element	Elemental emission factor, mg/MJ				Elemental emission rate, kg/h			
	Plant D				Plant D			
	<8.3 μm	<3.4 μm	<0.92 μm	<0.30 μm	<8.3 μm	<3.4 μm	<0.92 μm	<0.30 μm
Na	0.004	0.003	0.003	0.007	0.016	0.014	0.013	0.029
Mg	0.011	0.007	0.009	0.003	0.042	0.028	0.036	0.012
Al	0.070	0.042	0.041	0.016	0.027	0.175	0.173	0.066
Si	0.130	0.051	0.063	0.021	0.506	0.215	0.266	0.089
P	0.070	0.104	0.058	0.023	0.273	0.437	0.242	0.095
S	1.909	2.379	1.280	0.449	7.449	10.013	5.393	1.891
Cl	0.007	0.008	0.004	0.002	0.026	0.033	0.018	0.009
K	0.008	0.007	0.004	-	0.030	0.298	0.018	0.002
Ca	0.037	0.027	0.032	0.010	0.143	0.114	0.136	0.040
Ti	0.004	0.003	0.003	0.001	0.016	0.013	0.012	0.004
V	0.001	0.001	0.001	-	0.003	0.002	0.005	0.001
Cr	0.001	-	-	0.001	0.004	0.002	0.001	0.003
Mn	0.001	-	-	-	0.002	0.001	0.001	0.001
Fe	0.037	0.032	0.042	0.010	0.145	0.134	0.177	0.044
Ni	0.001	-	-	0.006	0.003	0.001	0.001	0.002
Zn	0.002	0.001	0.001	0.004	0.007	0.006	0.001	0.017
Ga	-	-	-	-	0.002	0.001	0.001	0.001
As	0.001	0.001	0.001	0.001	0.006	0.003	0.003	0.003
Se	0.021	0.008	0.022	0.009	0.082	0.037	0.093	0.037
Br	0.001	-	-	-	0.004	0.002	0.001	0.002
Pb	0.002	0.001	0.001	0.001	0.008	0.004	0.004	0.004
Rb	0.001	0.001	-	0.001	0.006	0.003	0.002	0.004
Sr	0.001	0.001	0.001	0.001	0.006	0.002	0.002	0.003

SULFUR EMISSIONS

The CCS and an SO₂ continuous monitor were used to obtain sulfur emission data at each plant tested. Particulate sulfate, H₂SO₄, and SO₂ emission data were obtained from the CCS samples while SO₂ was monitored continuously with a Teco Model 40 continuous monitor. Tables 4-20 through 4-22 summarize the sulfur emission data for the five plants tested.

SULFUR DIOXIDE

Sulfur dioxide measurements made by the CCS and CEM compared favorably at all plants tested. A systems relative accuracy check was determined according to the Federal Register, Vol. 44, No. 197, Section 6.5 by using the CCS results as equivalent to the reference method. In all cases, the system relative accuracy was within the specified limit of 20 percent.

Based on the SO₂ emission data from Plants A, B, and C, approximately 96 percent of the sulfur in the coal was converted to sulfur dioxide. An emission factor must be based on the percent of sulfur present in the coal being burned. For power plants equipped with an ESP only, an SO₂ emission factor of 96 percent of the coal sulfur content is recommended.

Plants D and E have an ESP for particulate control and an FGD system for SO₂ removal. Tests at Plant D indicated that the FGD system was removing approximately 70 percent of the sulfur dioxide in the flue gas. This SO₂ collection efficiency is based on the coal analysis and outlet test data since no inlet testing

TABLE 4-20. GROUP I SULFUR EMISSION DATA

Plant/ run	Boiler load, MW	Sulfur dioxide				Sulfuric acid mist		Sulfates (particulate)	
		CCS ^a		CEM ^b		CCS		CCS	
		mg/MJ	kg/h	mg/MJ	kg/h	mg/MJ	kg/h	mg/MJ	kg/h
Plant B									
1	85	1230	1212	c	c	-	-	0.09	0.09
2	135	770	1222	d	1166	5.14	8.1	<0.07	<0.12
3	106	880	1122	c	c	7.61	9.7	-	-
4	97	1090	1310	1120	1220	9.25	11.1	<0.08	<0.10
5	101	980	1220	1120	1082	5.40	6.7	<0.08	<0.10
6	95	900	1034	690	816	5.15	5.9	-	-
7	114	670	822	650	838	3.56	4.3	0.08	0.10
8	102	740	934	850	1060	4.70	5.9	<0.08	<0.10
9	109	40	1194	1060	1204	3.44	3.9	<0.09	<0.10
10	89	770	682	740	776	3.56	3.1	<0.10	<0.08
11	88	780	750	980	930	2.86	2.8	<0.10	0.10
12	95	850	918	670	918	2.59	2.8	<0.09	<0.10

^aControlled condensate system sampling method.

^bContinuous monitor sampling method.

^cContinuous SO₂ monitor not in operation.

^dContinuous O₂ monitor not in operation.

- Offline.

TABLE 4-21. GROUP II SULFUR EMISSION DATA

Plant/ run	Boiler load, MW	Sulfur dioxide				Sulfuric acid mist		Sulfates (particulate)	
		CCS ^a		CEM ^b		CCS		CCS	
		mg/MJ	kg/h	mg/MJ	kg/h	mg/MJ	kg/h	mg/MJ	kg/h
Plant C									
1	142	550	1035	-	-	0.57	1.08	1.08	2.03
2	130	660	936	690	1007	1.10	1.56	1.10	1.56
3	150	670	1038	760	1238	2.27	3.50	0.57	0.88
4	145	760	1274	670	1316	0.59	0.99	1.01	1.70
5	153	690	1461	-	-	0.39	0.83	-	-
6	147	750	1450	570	1197	0.56	1.09	0.77	1.49
7	159	800	1596	700	1545	0.38	0.76	0.51	1.01
8	162	790	1710	650	1658	-	-	-	-
9	157	600	1210	540	1256	0.73	1.49	1.02	2.08
10	156	080	2213	830	1878	1.63	3.33	0.35	0.72
Plant E									
1	169	710	1381	400	791	15.6	30.5	-	-
2	169	630	1126	490	901	14.5	25.9	0.16	0.29
3	160	430	849	480	879	14.2	27.8	0.16	0.32
4	175	490	1956	450	843	14.4	28.4	0.08	0.16
5	146	600	1017	540	879	16.8	28.3	0.16	0.28
6	175	680	1343	600	1173	12.2	24.2	0.08	0.15
7	167	630	1231	590	1164	14.8	29.1	0.08	0.16
8	175	670	1340	800	1473	15.6	31.1	0.17	0.33
9	144 ^c	390	626	390	627	17.8	28.5	0.93	1.49
10	144 ^d	2130	3413	-	-	18.0	28.9	3.76	6.02
11	175 ^c	530	1047	450	912	15.7	31.2	0.18	0.35
12	175 ^d	2570	5122	-	-	23.8	47.3	2.23	4.44

^aControlled condensate system sampling method.^bContinuous monitoring sampling method.^cOutlet.^dInlet.

TABLE 4-22. GROUP III SULFUR EMISSION DATA

Plant/ run	Boiler load, MW	Sulfur dioxide				Sulfuric acid mist		Sulfates (particulate)	
		CCS ^a		CEM ^b		CCS		CCS	
		mg/MJ	kg/h	mg/MJ	kg/h	mg/MJ	kg/h	mg/MJ	kg/h
Plant A									
1	601	740	4167	-	-	2.21	12.3	<0.61	<0.34
2	576	540	3096	530	2905	2.06	11.7	<0.57	<0.33
3	590	700	4100	550	3001	2.43	14.2	<0.59	<0.35
4	604	610	3384	450	2607	2.51	14.0	<0.63	<0.35
5	461	520	2586	750	3594	1.44	7.2	<0.60	<0.30
6	602	810	4556	600	3660	2.04	11.5	<0.64	<0.36
7	597	630	3856	480	3024	1.27	7.7	<0.60	<0.37
8	600	770	4328	660	4077	3.47	19.6	<0.67	<0.38
9	602	710	4260	690	4101	3.35	20.0	<0.62	<0.37
10	598	800	4691	850	5122	2.78	16.3	<0.63	<0.37
11	598	680	4131	-	-	2.80	16.9	<0.62	<0.38
Plant D									
1	346	870	3081	640	2083	21.0	74.4	0.80	2.82
2	333	770	3157	610	2131	15.1	61.8	0.61	2.48
3	281	1060	2982	780	1830	26.4	74.1	0.69	1.92
4	399	1020	4327	940	3017	19.3	82.1	0.48	2.05
5	177	740	1532	620	1216	16.0	33.1	0.60	1.23
6	361	860	3420	960	3172	16.1	63.8	0.42	1.65
7	372	1150	4599	040	4024	21.6	86.2	-	-
8	393	860	3789	010	4312	19.1	84.4	0.63	2.76
9	332	990	3218	930	3177	21.9	71.3	0.85	2.77
10	339	730	2701	770	2691	16.6	60.4	0.44	1.61

^aControlled condensate system sampling method.^bContinuous monitoring sampling method.

was performed at this plant. Based on the coal analysis and limited inlet test data, the FGD at Plant E demonstrated an SO₂ collection efficiency of approximately 80 percent. Projections for SO₂ emissions for plants with an ESP and FGD should consider the percent sulfur in the coal, the conversion of sulfur in the coal to SO₂, and the SO₂ removal efficiency of the FGD.

SULFURIC ACID MIST

Emission data obtained at Plants A and B showed that approximately 0.4 percent of the sulfur present in the coal was converted to sulfuric acid mist (H_2SO_4). Plant C was not operating properly during the test period, and poor combustion can influence H_2SO_4 emissions. Therefore, data from Plant B should be used for plants in Group II that are controlled by an ESP only. Plants A and B were using a coal with a sulfur content of approximately 1 percent.

Plants D and E were burning a coal with a sulfur content of approximately 3.8 and 3.3 percent, respectively. Limited inlet test data at Plant E indicate that approximately 0.5 percent of the sulfur present in the coal was converted to H_2SO_4 . The average emission factor was estimated to be 20.9 mg/MJ. Outlet tests were conducted simultaneously with the inlet tests, and these results showed an average emission factor of 16.8 mg/MJ of H_2SO_4 . Approximately 20 percent of the H_2SO_4 was removed by the FGD system. Tests at Plant D were conducted at the outlet only, and the outlet H_2SO_4 emission factor averaged 19.3 mg/MJ.

Based on the available data, we can estimate the emission rate at Plant D by using the FGD efficiency tests at Plant E. The sulfur content of the coal at Plant D averaged 3.85 percent and had an average heat content of 24,618 KJ/kg. The estimated H_2SO_4 emission factor was 18.9 mg/MJ compared with the measured emission factor of 19.3 mg/MJ.

For plants equipped with an ESP only, sulfuric acid mist emission rates should be estimated on the basis of the percent sulfur in the coal and the percent sulfur converted to H_2SO_4 . For plants controlled by an ESP and an FGD system, an H_2SO_4 removal efficiency of 20 percent should also be taken into account.

PARTICULATE SULFATE

Particulate sulfate was determined from the particulate collected in the probe and on the filter in the CCS sampling train. The probe and filter were maintained at a temperature of 288°C to prevent condensation of sulfuric acid mist on the particulate or filter. The average mass emission rate determined for each plant are presented in the following three selected groups.

Group I

Emissions of particulate sulfate from Plant B averaged <0.09 mg/MJ which corresponds to a mass emission rate of <0.10 kg/h.

Group II

Particulate emissions at Plant C were excessively high during the testing period. Particulate sulfate emissions were also higher than other similar units tested. Therefore, the emission data from Plant B should be used instead of Plant C to project regional particulate sulfate emissions.

Particulate sulfate emissions from Plant E averaged 0.22 mg/MJ and the mass emission rate was 0.39 kg/h. CCS inlet and outlet tests showed that the FGD system reduced the particulate sulfate entering the scrubber by an average of 84 percent.

Group III

Test results at Plant A showed that the particulate sulfate emissions averaged <0.06 mg/MJ while the mass emission rate averaged <0.34 kg/h. At Plant D, the particulate sulfate emissions averaged 0.61 mg/MJ and the average mass emission rate was 2.1 kg/h.

Particulate sulfate results as determined by the CCS and the sulfur present in the particle size distribution samples were compared. The sulfur in the particle size distribution samples was determined by XRF analysis and all the sulfur was assumed to be present as particulate sulfates. The CCS sampling probe and filter were maintained at a temperature of 288°C during the sampling period. Maintaining this temperature would minimize any H_2SO_4 from adsorbing onto the particulate collected by the CCS sampling train. The instack impactor was at stack temperature ($\sim 150^\circ C$) at Plants A, B, and C (ESP control only) and the impactor was heated to approximately 140°C at Plants D and E (ESP and FGD controls) to prevent moisture condensing in the impactor.

The concentration of particulate sulfate, determined from the CCS sampling train, was approximately 90 percent of the particulate sulfur collected in the instack impactor at Plants A, B, and C. This close agreement indicates the sulfuric acid mist was in the gaseous phase and was not adsorbed onto the particulate in the gas stream. The concentration of particulate sulfate, determined from the CCS sampling train, averaged 50 percent of the particulate sulfate collected by the instack impactor at Plants D and E. This data suggests a portion of the sulfuric acid mist was adsorbed onto the particulate. Since the stack temperature was approximately 70°C at Plants D and E, gaseous and H_2SO_4 aerosols would be present as indicated in the test data.

The trace element analysis of the particle size distribution samples also showed that the sulfur content of the particulate

increased as the particle size decreased. Enrichment of sulfur in the smaller fractions occurred at each plant tested.

GASEOUS NO₂ AND NO_x EMISSIONS

At each plant, NO₂ and NO_x emissions data were continuously monitored. Based on an average of the recorded data for the five plants tested, approximately 3 percent of the nitrogen oxide emissions exiting the control devices were present in the form of NO₂ and the remaining 97 percent of the nitrogen emissions were present as NO. There was no correlation between emission factors calculated for each plant tested since nitrogen oxide emissions are dependent on various operating parameters: residence time, burner configuration, percent excess air, etc. Since each plant operated under different parameters, the nitrogen oxide emission factors would be expected to vary between the plants tested.

Table 4-23 through 4-25 present the nitrogen oxide emission data for each group of plants. The following is a summary of the nitrogen oxide emission data; an emission factor is presented for each group.

Group I

Continuous monitor testing at Plant B showed that the average mass emission rate was <13.5 kg/h for nitrogen dioxide (NO₂). The NO_x mass emission rate was 405 kg/h. The respective emission factors for NO₂ and NO_x were <9.2 and 278 mg/MJ.

Group II

Continuous monitor testing at Plant C showed that the average mass emission rates were <18.5 and 408 kg/h for NO₂ and NO_x, respectively. The respective emission factors for NO₂ and

TABLE 4-23. GROUP I NITROGEN OXIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM CONTINUOUS MONITORING DATA

Plant/ run	Boiler load, MW	NO _x		NO ₂	
		Emission factor, mg/MJ	Emission rate, kg/h	Emission factor, mg/MJ	Emission rate, kg/h
Plant B					
1	85	-	-	-	-
2	135	320	510	< 8.6	<14
3	106	320	496	<13.6	<21
4	97	280	423	<13.0	<19
5	101	390	417	<11.2	<12
6	95	290	360	< 9.7	<12
7	114	280	411	< 8.6	<13
8	102	290	371	< 7.7	<10
9	109	300	421	< 6.8	<10
10	89	270	285	< 9.5	<10
11	88	300	356	<11.4	<13
12	95	300	406	<10.3	<14

TABLE 4-24. GROUP II NITROGEN OXIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM CONTINUOUS MONITORING DATA

Plant/ run	Boiler load, MW	NO _x		NO ₂	
		Emission factor, mg/MJ	Emission rate, kg/h	Emission factor, mg/MJ	Emission rate, kg/h
Plant C					
1	142	-	-	-	-
2	130	310	410	<15.8	<11
3	150	240	383	< 4.7	< 8
4	145	230	445	< 4.3	< 9
5	153	230	464	<11.0	<23
6	147	220	432	<13.0	<26
7	159	160	365	< 9.5	<21
8	162	140	347	< 8.9	<22
9	157	-	-	-	-
10	156	180	418	<12.4	<28
Plant E					
1	169	280	569	< 2.2	< 5
2	170	290	541	< 3.7	< 7
3	169	380	702	< 7.6	<14
4	169	350	681	< 7.3	<14
5	160	340	559	< 5.3	< 9
6	158	330	640	< 7.1	<14
7	175	400	790	< 3.7	< 7
8	174	460	857	< 4.1	< 8
9	146	340	546	< 8.0	<13
10	150	380	752	< 5.1	<10

TABLE 4-25. GROUP III NITROGEN OXIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM CONTINUOUS MONITORING DATA

Plant/ run	Boiler load, MW	NO _x		NO ₂	
		Emission factor, mg/MJ	Emission rate, kg/h	Emission factor, mg/MJ	Emission rate, kg/h
Plant A					
1	601	-	-	-	-
2	576	500	2137	19.1	111
3	590	420	2295	8.8	48
4	604	400	2351	8.0	47
5	461	520	2448	17.5	82
6	602	530	3222	12.6	77
7	597	510	3199	8.2	51
8	600	-	-	-	-
9	602	540	3463	11.1	71
10	598	610	3708	9.9	60
11	598	540	3336	11.1	69
Plant D					
1	346	180	600	< 4.1	<13
2	333	140	457	< 4.2	<14
3	281	150	351	< 5.1	<12
4	399	170	627	< 4.2	<15
5	177	150	292	< 6.3	<12
6	361	180	672	< 4.4	<16
7	372	220	841	< 4.3	<17
8	393	210	868	< 4.3	<18
9	332	220	777	< 9.1	<32
10	339	200	725	< 6.5	<23

NO_x were <10.0 and 213.8 mg/MJ for a plant equipped with an ESP as the only emission control device.

Continuous monitoring testing at Plant E showed that the average mass emission rates were <10.1 and 663.7 kg/h for NO_2 and NO_x , respectively. The emission factors for NO_2 and NO_x were <5.4 and 355.0 mg/MJ, respectively, for a plant equipped with an ESP and SO_2 scrubber to control emissions.

Group III

Continuous monitor testing at Plant A showed that the average mass emission rates were 60.4 and 3082.0 kg/h for NO_2 and NO_x , respectively. The respective emission factors for NO_2 and NO_x were 10.0 and 507.1 mg/MJ for a plant equipped with an ESP as the only emission control device.

Continuous monitoring testing at Plant D showed that the average mass emission were $\leq$ 18.5 and 695.9 kg/h for NO_2 and NO_x , respectively. The respective emission factors for NO_2 and NO_x were <5.1 and 190 mg/MJ for a plant equipped with an ESP and SO_2 scrubber to control emissions.

PARTICULATE AND GASEOUS CHLORIDE EMISSIONS

At each plant tested, the samples taken by the Controlled Condensation System (CCS) were analyzed for particulate chloride and gaseous chloride (as HCl). Particulate chloride and gaseous HCl analyses at Plants A, B, and C indicate that at least 99 percent of the chloride emissions exiting the particulate control device are in a gaseous phase. This percentage should hold consistent for all coal-fired plants operating with an ESP as the only control device.

The chloride analysis shows that the measured chlorides, coal composition, and emission factors compared very closely. For Plants A, B, and C, the emission factors for particulate and gaseous chlorides were similar, and the emission rates for all power plants equipped with ESP's can be based on the chloride content of the coal. Average emission factors and mass emission rates were determined for each plant. The results of the analyses of each sample are broken down into the three defined groups as shown in Tables 4-26 through 4-28. The following is a summary of the test data and recommended emission factors for each group of power plants.

Group I

Outlet testing at Plant B showed that the average mass emission rate was <0.05 kg/h for particulate chloride and 40.9 kg/h for gaseous HCl. The emission factors for particulate chloride and gaseous HCl were <0.04 and 32.2 mg/MJ, respectively.

TABLE 4-26. GROUP I - CHLORIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM ANALYSIS OF CCS SAMPLES

Plant/ run	Load, MW	Emission factor, mg/MJ		Mass emission rate, kg/h	
		Particulate chloride	Gaseous HCl	Particulate chloride	Gaseous HCl
Plant B					
1	84	<0.047	22.6	<0.046	24.3
2	121	<0.038	8.2	<0.060	23.4
3	135	<0.037	18.9	<0.058	32.4
4	102	<0.041	32.7	<0.052	43.3
5	90	<0.041	31.2	<0.050	40.0
6	106	<0.040	43.4	<0.050	55.0
7	96	<0.043	40.7	<0.050	28.1
8	120	<0.039	40.1	<0.050	53.1
9	101	<0.042	28.5	<0.052	37.2
10	107	<0.050	50.4	<0.052	57.8
11	80	<0.035	23.5	<0.044	29.9
12	85	<0.048	38.1	<0.046	38.4
13	100	<0.047	41.9	<0.050	47.7

TABLE 4-27. GROUP II - CHLORIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM ANALYSIS OF CCS AND COAL SAMPLES

Plant/ run	Load, MW	Emission factor, mg/MJ			Mass emission rate, kg/h		
		Particulate chloride, CCS	Gaseous HCL, CCS	Chloride ^a content of coal	Particulate chloride, CCS	Gaseous HCl, CCS	Chloride ^a content of coal
Plant C							
1	141	<0.036	17.4		<0.050	23.0	
2	135	0.412	23.0		<0.024	27.2	
3	151	<0.041	45.1		<0.080	86.5	
4	145	0.339	18.1		<0.400	21.3	
5	152	0.065	62.1		0.100	101.1	
6	160	<0.035	64.0		<0.060	106.3	
7	160	<0.032	57.8		<0.050	89.7	
8	168	0.128	49.9		0.220	84.3	
9	156	1.606	39.4		2.420	59.4	
10	154	1.193	35.4		2.82	83.4	
Plant E							
1	170	<0.040	0.63	82.4	<0.15	1.21	162
2	169	<0.036	<0.040	13.8	<0.15	< 0.08	-
3	158	<0.038	<0.040	97.7	<0.15	< 0.08	214
4	174	<0.040	0.160	77.9	<0.16	< 0.08	152
5	150	<0.041	<0.020	71.4	<0.15	0.30	164
6	175	<0.039	<0.040	88.9	<0.16	< 0.80	179
7	175	<0.043	<0.050	69.8	<0.16	< 0.08	127
8	175	<0.040	<0.040	63.5	<0.17	< 0.09	130
9	151	<0.046	0.910	93.0	<0.15	1.50	152
10	175	<0.043	<0.050	60.0	<0.15	< 0.08	120

^a Assumes that all the chloride in the coal is converted to HCL.

TABLE 4-28. GROUP III - CHLORIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM ANALYSIS OF CCS AND COAL SAMPLES

Plant/ run	Load, MW	Emission factor, mg/MJ			Mass emission rate, kg/h		
		Particulate chloride, CCS	Gaseous HCL, CCS	Chloride ^a content of coal	Particulate chloride, CCS	Gaseous HCL, CCS	Chloride ^a content of coal
Plant A							
1	601	<0.030	46.5	43.1	<0.17	272	252
2	569	<0.029	37.8	145.8	<0.16	211	815
3	590	<0.029	41.2	20.6	<0.17	246	123
4	604	<0.030	44.0	25.1	<0.18	263	150
5	479	<0.031	38.5	18.4	<0.15	189	90
6	602	<0.032	44.3	37.5	<0.18	250	211
7	600	<0.029	42.9	44.9	<0.19	274	287
8	601	<0.034	42.9	44.3	<0.19	238	247
9	602	<0.032	48.4	37.3	<0.19	282	217
10	598	<0.032	44.7	40.7	<0.19	263	240
11	598	<0.035	49.0	40.6	<0.19	267	221
Plant D							
1	339	<0.039	1.02	43.7	<0.13	3.4	157
2	380	<0.034	0.13	24.9	<0.13	0.5	104
3	336	<0.042	0.17	59.7	<0.11	0.4	170
4	392	<0.034	0.94	36.0	<0.13	3.6	157
5	176	<0.049	1.57	37.0	<0.10	3.0	89
6	320	<0.037	0.66	37.4	<0.13	2.3	141
7	392	<0.036	1.02	81.8	<0.13	3.6	336
8	394	<0.035	0.55	88.9	<0.15	2.4	396
9	332	<0.043	0.19	74.7	<0.13	3.5	243
10	334	<0.035	0.95	90.9	<0.12	2.9	238

^a Assumes that all the chloride in the coal is converted to HCl.

Group II

Outlet testing at Plant C showed that the average mass emission rate was <0.62 kg/h for particulate chloride and 68.2 kg/h for gaseous HCl. The emission factors for particulate chloride and gaseous HCl were <0.39 and 41.2 mg/MJ, respectively for a plant equipped with an ESP only. Outlet testing at Plant E showed that particulate chloride and gaseous HCl had average mass emission rates of <0.08 and <0.19 kg/h. For a plant equipped with an ESP and SO_2 scrubber, the emission factors for particulate chloride and gaseous HCl were <0.04 and <0.20 mg/MJ, respectively. The results of the coal analysis yielded an average mass emission rate of 155.6 kg/h and an emission factor of 78.3 mg/MJ. The SO_2 scrubber thus collected 99.7 percent of the gaseous chlorides.

Test results on Plant E show that SO_2 scrubbers are capable of removing 99 percent of the chlorides. This is based on a comparison of the emission factors for similar plants and on limited efficiency test data at Plant E. The chlorides removed by the scrubber are almost totally in the gaseous phase since particulate chloride results compare favorably with plants equipped with ESP's only.

Group III

The outlet testing at Plant A showed that the average mass emission rate was <0.18 kg/h for particulate chloride. The gaseous HCl mass emission rate was 250.6 kg/h. The emission factors for particulate and gaseous HCl were <0.03 and 43.7 mg/MJ

for a plant equipped with an ESP only. The results of the coal analyses yielded an average mass emission rate of 259.4 kg/h and an emission factor of 43.7 mg/MJ.

Outlet testing at Plant D showed that the average mass emission rate for particulate chloride was <0.13 kg/h. The gaseous HCl mass emission rate was 2.6 kg/h. For a plant equipped with an ESP and a SO₂ scrubber, the emission factors for particulate chloride and gaseous HCl were <0.038 and 0.82 mg/MJ, respectively. The results of the coal analysis yielded an average mass emission rate of 203.1 kg/h and an emission factor of 57.5 mg/MJ. The SO₂ scrubber collected 98.6 percent of the gaseous chlorides.

PARTICULATE AND GASEOUS FLUORIDES

At each plant tested, the CCS samples were analyzed for particulate and gaseous fluorides (as HF). Analyses of the particulate fluoride and gaseous HF at Plants A, B, and C indicated that about 99 percent of the fluoride emissions exiting the control device are in the gaseous phase. This percentage should be consistent for all coal-fired power plants operating with an ESP as the only control device. The emission factors for particulate fluoride and gaseous HF for Plants A, B, and C were in close agreement.

The scrubber at Plant D removes approximately 98 percent of the fluorides. These fluorides are almost totally in the gaseous phase since particulate fluoride results compare fairly close with the plants equipped with an ESP. The scrubber at Plant E removes about 95 percent of the fluorides, which are almost all in the gaseous phase.

Tables 4-29 through 4-31 present fluoride emission data for each group of plants. Following is a summary of the fluoride emission data; an emission factor for each group is presented.

Group I

The outlet testing at Plant B showed that the average mass emission rate was <0.05 kg/h for particulate fluoride. The gaseous HF mass emission rate was 4.0 kg/h. Respective emission factors for particulate fluoride and gaseous HF were <0.04 and 3.0 mg/MJ.

TABLE 4-29. GROUP I - FLUORIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM ANALYSIS OF CCS SAMPLES

Plant/ run	Load, MW	Emission factor, mg/MJ		Mass emission rate, kg/h	
		Particulate fluoride	Gaseous HF	Particulate fluoride	Gaseous HF
Plant B.					
1	84	<0.047	3.36	<0.050	3.62
2	121	<0.038	1.20	<0.070	3.78
3	135	<0.037	2.72	<0.060	4.80
4	102	<0.031	3.60	<0.050	4.78
5	90	<0.031	3.63	<0.050	4.66
6	106	<0.028	3.19	<0.050	4.04
7	96	<0.031	3.00	<0.050	3.54
8	120	<0.029	0.46	<0.050	0.62
9	101	<0.031	2.39	<0.050	3.12
10	107	<0.045	3.38	<0.050	3.88
11	80	<0.035	2.66	<0.040	3.38
12	85	<0.048	3.53	<0.050	3.54
13	100	<0.047	3.51	<0.050	4.00

TABLE 4-30. GROUP II - FLUORIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM ANALYSIS OF CCS SAMPLES

EMISSION RATES DETERMINED FROM ANALYSIS OF CCS SAMPLES					
Plant/ run	Load, MW	Emission factor, mg/MJ		Mass emission rate, kg/h	
		Particulate fluoride	Gaseous HF	Particulate fluoride	Gaseous HF
Plant C					
1	141	<0.036	2.99	<0.05	
2	135	<0.137	1.91	0.06	3.96
3	151	<0.041	2.99	<0.08	2.28
4	145	<0.043	2.12	<0.05	5.74
5	152	<0.033	3.35	<0.05	2.48
6	160	<0.035	2.41	<0.05	5.46
7	160	<0.032	4.39	<0.06	4.00
8	168	<0.032	3.14	<0.05	6.82
9	156	<0.037	4.66	<0.05	5.32
10	154	<0.035	3.72	<0.05	6.92
				<0.08	8.78
Plant E					
1	170	<0.040	0.157	<0.08	
2	169	<0.036	0.215	<0.08	0.30
3	158	<0.038	0.149	<0.08	0.46
4	174	<0.040	0.159	<0.08	0.30
5	150	<0.041	<0.041	<0.08	0.32
6	175	<0.039	<0.039	<0.08	<0.08
7	175	<0.043	<0.043	<0.08	<0.08
8	175	<0.040	<0.040	<0.08	<0.08
9	151	<0.046	<0.046	<0.09	<0.09
10	175	<0.043	<0.046	<0.08	<0.08
			<0.083	<0.08	<0.08

TABLE 4- 31. GROUP III - FLUORIDE EMISSION FACTORS AND EMISSION RATES
DETERMINED FROM ANALYSIS OF CCS SAMPLES

DETERMINED FROM ANALYSIS OF CCS SAMPLES					
Plant/ run	Load, MW	Emission factor, mg/MJ		Mass emission rate, kg/h	
		Particulate fluoride	Gaseous HF	Particulate fluoride	Gaseous HF
Plant A					
1	601	<0.058	3.40	<0.34	19.9
2	569	<0.058	3.33	<0.33	18.6
3	590	<0.058	3.54	<0.34	20.6
4	604	<0.059	3.40	<0.35	20.2
5	479	<0.061	2.79	<0.30	13.9
6	602	<0.064	3.72	<0.35	20.2
7	600	<0.058	3.56	<0.37	22.9
8	601	<0.068	3.93	<0.38	21.9
9	602	<0.064	4.65	<0.37	27.1
10	598	<0.063	4.15	<0.37	24.5
11	598	<0.069	3.93	<0.37	21.3
Plant D					
1	339	<0.039	<0.039	<0.26	<0.13
2	380	<0.034	<0.034	<0.25	<0.13
3	336	<0.042	<0.042	<0.21	<0.11
4	392	<0.034	0.135	<0.26	0.51
5	176	<0.049	0.196	<0.19	0.38
6	320	<0.037	0.146	<0.25	0.51
7	392	<0.036	<0.036	<0.26	<0.13
8	394	<0.035	<0.035	<0.30	<0.15
9	332	<0.043	0.170	<0.25	0.50
10	334	<0.037	0.147	<0.23	0.45

Group II

The outlet testing at Plant C showed that the average mass emission rates were <0.06 and 5.5 kg/h for particulate fluoride and gaseous HF, respectively. Respective emission factors for particulate fluoride and gaseous HF were <0.036 and 3.30 mg/MJ for a plant equipped with an ESP only.

Outlet testing at Plant E showed that the average mass emission rates were <0.08 and <0.19 kg/h for particulate fluoride and gaseous HF, respectively. Respective emission factors for particulate fluoride and gaseous HF were <0.04 and <0.10 mg/MJ for a plant equipped with an ESP and SO₂ scrubber.

Group III

Outlet testing at Plant A showed an average mass emission rate of <0.36 and 21.7 kg/h for particulate fluoride and gaseous HF, respectively. Respective emission factors for particulate fluoride and gaseous HF were <0.062 and 3.76 mg/MJ for a plant equipped with an ESP only.

Outlet testing at Plant D showed an average mass emission rate of <0.25 and <0.29 kg/h for particulate fluoride and gaseous HF, respectively. Respective emission factors for particulate fluoride and gaseous HF were <0.037 and <0.087 mg/MJ for a plant equipped with an ESP and SO₂ scrubber.

SECTION 5

POLLUTANT MASS EMISSION RATES FOR PLANTS PRESENTLY OPERATING IN THE STUDY REGION

Data presented in Section 4 of this report were used to project pollutant mass emission rates for each coal-fired power-plant unit operating in the study region. The emission factor used to calculate the pollutant mass emission rates for each plant depended on the type of control equipment utilized, age, and size of the unit. Emission rates are presented for each type of pollutant measured on a total yearly average basis and for the three separate defined groups.

FILTERABLE PARTICULATE EMISSIONS

The emission factor used to calculate the filterable particulate emissions for the power plants in each of the three separate groups is an average value derived by averaging the emission factors calculated for each plant tested. This procedure was used since the plants tested were operating at various times in their periodic maintenance schedule. Data obtained for Plant C was not used in determining the average mass emission rate because this plant was operating abnormally during the testing period.

The total yearly average filterable particulate mass emission rate for all the power plants operating in the study region is 3252 kg/h. Figure 5-1 presents the total monthly filterable particulate mass emission rates. The yearly average filterable particulate mass emission rate for plants in the Group I category is 354 kg/h as shown in Table 5-1. This compares to a yearly average filterable particulate emission rate of 909 and 1989 kg/h for power plants in Groups II and III, respectively, as shown in Tables 5-2 and 5-3.

Figures 5-2 through 5-4 present the total filterable particulate mass emission rates on a monthly basis for the three separate groups.

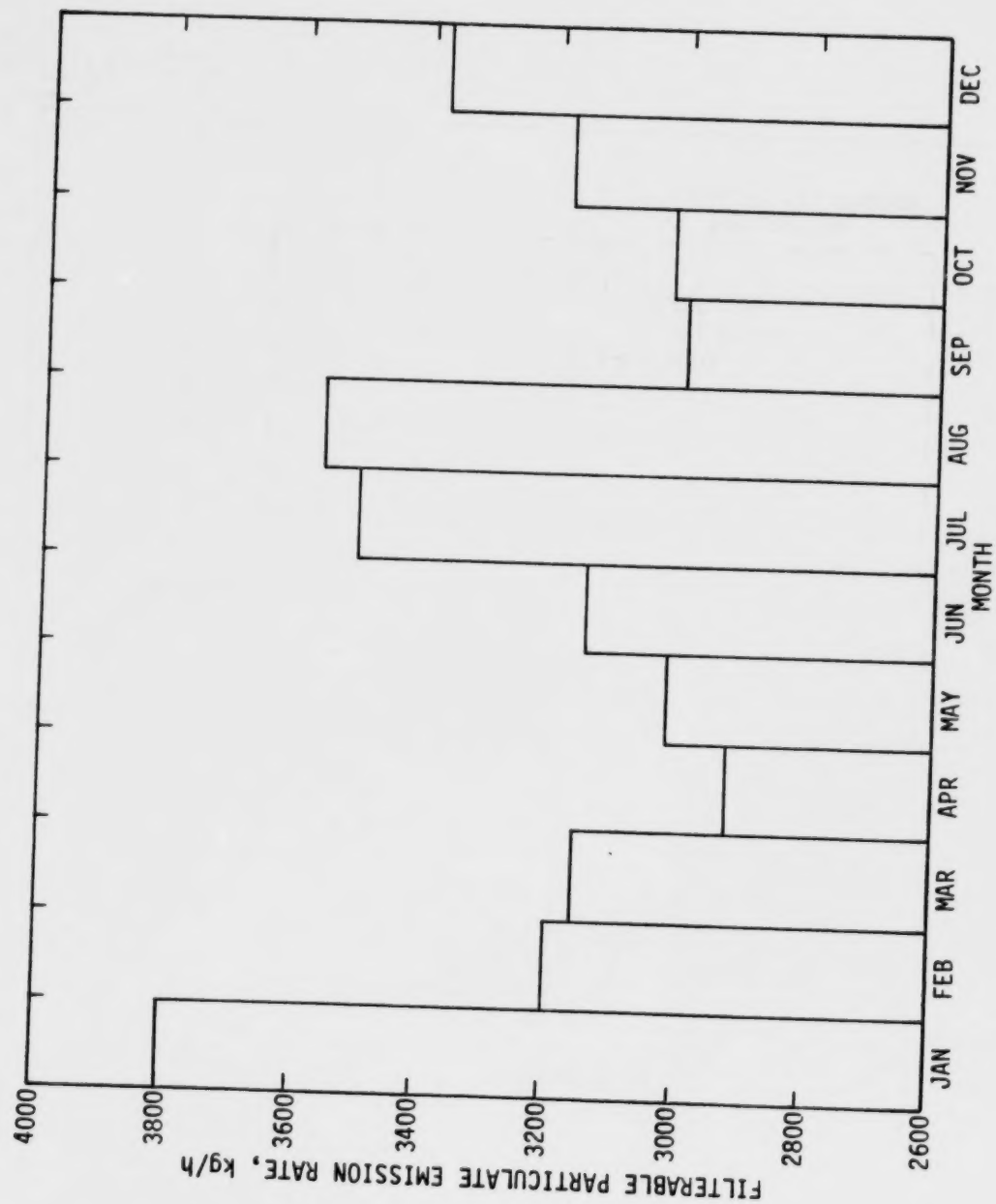


Figure 5-1. Total monthly filterable particulate emissions.

TABLE 5-1. GROUP I - MONTHLY POWER PLANTS FILTERABLE PARTICULATE MASS EMISSION RATE
EMISSION FACTOR = 46.7 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly filterable particulate emissions, kg/h												Average yearly filterable particulate emissions, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run ¹	3/69	12.35	11.7	9.1	7.9	13.6	5.4	1.7	0.0	1.6	0.0	0.2	2.2	6.6	5.0
	4/69	13.31	7.6	6.5	8.8	1.4	1.9	0.8	0.0	5.1	1.0	0.0	4.8	5.4	3.6
	5/71	12.85	9.0	0.0	2.4	0.4	0.0	0.0	1.3	8.7	1.0	0.0	0.9	0.3	2.0
	6/71	13.00	6.2	0.0	0.8	0.0	3.5	1.1	0.4	7.8	1.4	0.0	0.0	0.4	1.8
Beckjord ³	1/115	11.28	52.2	50.1	52.0	44.2	49.7	44.6	39.1	41.0	43.9	43.9	42.4	39.4	45.2
	2/112.5	11.31	42.5	43.2	45.3	41.5	39.2	39.6	34.7	35.2	37.3	38.5	24.6	20.0	36.8
	3/125	11.27	36.9	56.7	61.9	51.6	46.9	55.4	37.3	53.6	37.8	23.1	23.5	50.5	44.6
	5/100	10.72	1.0	21.6	27.0	12.3	34.3	26.7	7.9	0.0	0.0	16.3	22.6	18.7	15.7
Tanners Creek ²	1/150	10.80	41.7	46.3	50.5	51.5	38.9	0.0	38.0	19.6	32.2	55.2	42.4	49.4	40.3
	2/150	10.82	51.0	58.9	52.3	40.6	67.0	62.2	24.3	17.7	34.2	51.7	42.7	44.6	45.6
	3/215	10.64	99.2	87.2	64.0	63.9	97.2	75.0	62.2	54.2	59.0	66.0	54.5	62.8	70.4
	1/112.5	11.71	62.2	53.9	32.8	35.6	30.7	8.8	0.0	31.2	10.1	0.0	4.1	1.8	22.6
Cane Run ²	2/112.5	11.28	44.8	43.8	11.3	23.2	27.5	18.2	22.5	22.5	9.8	17.5	0.0	0.0	20.1
			466.0	477.3	417.0	379.8	442.2	334.1	267.7	298.2	267.7	312.4	264.7	299.9	353.7
Total															

¹Heat rate values calculated from published data.

²Heat rate values from Electrical World Dictionary of Electric Utilities.

³Heat rate values provided by CG&E personnel.

TABLE 5-2. GROUP II - MONTHLY POWER PLANTS FILTERABLE PARTICULATE MASS EMISSION RATE
EMISSION FACTOR = 46.7 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly filterable particulate emissions, kg/h												Average yearly filterable particulate emissions, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord ³	4/163	12.54	74.8	80.0	81.6	74.6	59.4	33.1	58.1	86.2	75.6	68.6	62.1	60.7	67.9
	5/244	10.23	77.4	89.4	116.4	107.4	123.3	80.9	76.1	83.0	84.4	101.2	75.6	93.7	92.4
	6/168	9.63	73.3	68.3	70.4	66.8	73.1	48.6	65.6	75.4	66.6	43.4	0.0	2.7	54.5
Miami Fort ³ Clifty Creek ²	1/225	10.24	75.0	82.3	75.0	83.8	91.2	86.7	0.0	25.0	91.2	83.8	94.1	100.0	74.0
	2/224	10.14	84.1	85.6	76.6	91.6	36.1	3.0	90.1	90.1	97.7	102.2	96.2	100.7	79.5
	3/225	10.23	88.5	101.4	48.3	4.8	85.3	85.3	106.2	98.2	99.8	103.0	85.3	93.4	83.3
	4/225	10.23	35.0	0.0	67.0	84.5	102.0	94.7	88.9	72.9	87.4	75.8	94.7	80.2	73.6
	5/225	10.19	98.3	93.8	99.8	93.8	99.8	89.3	95.3	92.3	90.8	98.3	75.9	98.3	93.8
	6/225	10.22	85.4	76.4	100.4	97.4	101.9	94.4	94.4	64.4	0.0	58.4	97.4	88.4	79.9
Gallagher ¹	1/150	11.30	8.43	0.0	0.0	0.0	0.0	1.4	28.1	36.5	35.1	33.7	25.3	29.5	16.5
	2/150	10.59	19.7	47.9	47.9	43.6	35.2	40.8	43.6	29.6	33.8	36.6	32.4	36.6	37.3
	3/150	10.50	50.7	45.1	40.9	45.1	35.2	0.0	15.5	35.2	35.2	40.9	43.7	40.9	35.7
	4/150	11.54	40.9	2.8	0.0	0.0	11.3	33.8	40.9	39.5	33.8	28.2	38.0	39.5	25.7
Cane Run ²	3/147	11.36	48.1	48.5	31.6	29.6	36.2	21.6	15.6	36.9	29.1	8.0	18.7	19.3	28.6
	4/178	11.12	0.0	0.0	0.0	0.0	0.0	25.4	90.4	99.7	22.1	34.2	57.8	47.3	31.4
	5/183	10.96	39.1	32.3	37.9	22.9	16.4	37.8	33.6	38.3	28.4	36.8	20.5	32.9	35.1
Total			898.7	853.8	893.8	845.9	906.4	776.8	942.3	1003.2	911.0	953.1	917.7	964.1	909.2

¹Heat rate values calculated from published data.

²Heat rate values from Electrical World Dictionary of Electric Utilities.

³Heat rate values provided by CG&E personnel.

TABLE 5-3. GROUP III - MONTHLY POWER PLANTS FILTERABLE PARTICULATE MASS EMISSION RATE
EMISSION FACTOR = 46.7 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly filterable particulate emissions, kg/h												Average yearly filterable particulate emissions, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord ²	6/460	11.02	127.2	0.0	0.0	0.0	23.0	82.0	158.4	163.1	64.1	182.7	131.2	116.2	91.9
Stuart ²	1/610	10.67	239.3	187.8	210.8	172.1	28.9	210.7	213.3	233.2	87.2	261.2	168.2	244.3	188.1
	2/610	10.77	186.5	150.1	176.6	234.5	141.6	217.7	230.0	206.1	118.3	236.0	227.3	184.0	192.4
	3/610	10.07	186.6	173.1	184.7	84.3	228.5	176.9	216.4	207.6	176.4	190.5	136.1	221.6	181.9
	4/610	9.85	238.1	183.4	199.8	77.1	244.5	174.7	233.7	230.3	226.0	66.3	225.8	236.7	194.7
Miami Fort ²	7/500	10.79	165.9	84.6	191.0	176.5	131.2	139.2	186.3	153.4	162.0	84.4	203.7	214.1	157.7
	8/500	10.43	185.9	153.8	24.4	160.7	156.4	143.8	132.7	141.9	159.2	155.9	20.6	0.0	119.6
Tanners Creek ²	4/500	10.42	155.6	101.6	104.9	114.4	37.2	122.6	185.0	151.9	123.1	53.4	193.9	182.8	127.2
Ghent ¹	1/511	10.54	193.6	187.8	170.2	130.0	170.8	208.8	198.5	212.5	45.5	139.7	214.7	213.5	173.8
	2/511	10.55	262.4	195.9	123.1	127.5	83.7	27.1	100.0	88.2	160.0	37.0	33.8	112.4	112.6
Cane Run ²	6/277	10.96	97.1	64.3	74.0	66.3	82.1	79.9	72.5	86.8	66.8	29.6	66.7	94.7	73.4
M111 Creek ²	1/335	10.51	109.3	32.6	0.0	37.9	109.3	114.6	10.3	95.0	89.9	67.1	117.7	112.4	81.2
	2/326	10.55	128.4	110.0	108.4	102.4	57.3	96.6	106.2	71.5	105.2	101.0	119.7	99.2	100.5
	3/425	10.74	55.9	148.7	178.2	111.6	161.3	166.2	131.0	156.7	156.7	147.7	9.7	0.0	116.4
Spurlock ¹	1/300	11.31	108.2	102.4	101.0	79.6	54.3	77.8	85.7	83.3	73.5	0.0	76.7	83.9	77.2
Total			2440.0	1876.1	1847.1	1693.1	1665.4	2033.7	2295.2	2255.8	1813.9	1752.5	1995.8	2115.8	1988.6

¹ Heat rate values calculated from published data.

² Heat rate values from Electrical World Dictionary of Electric Utilities.

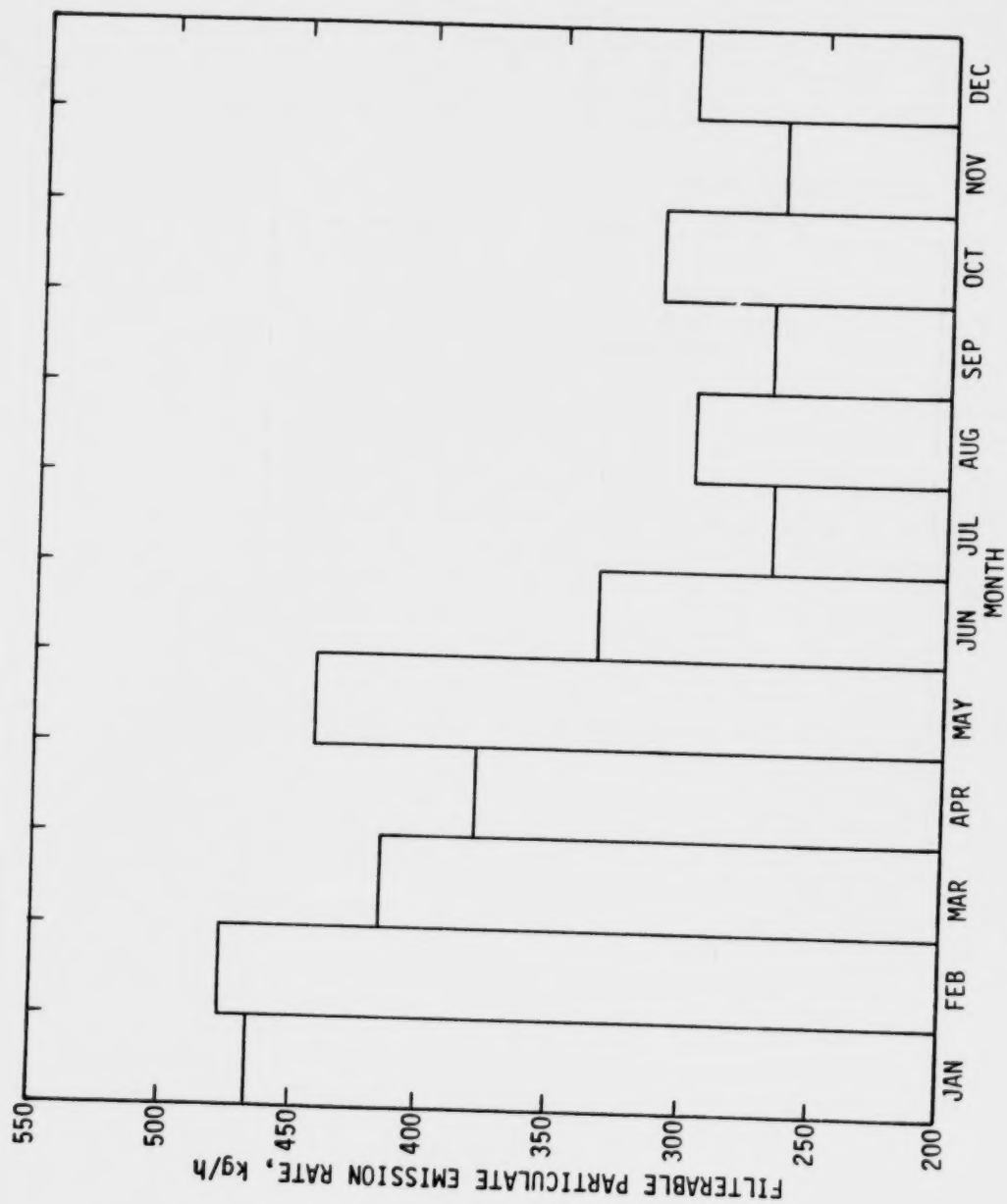


Figure 5-2. Group I - Monthly filterable particulate mass emissions.

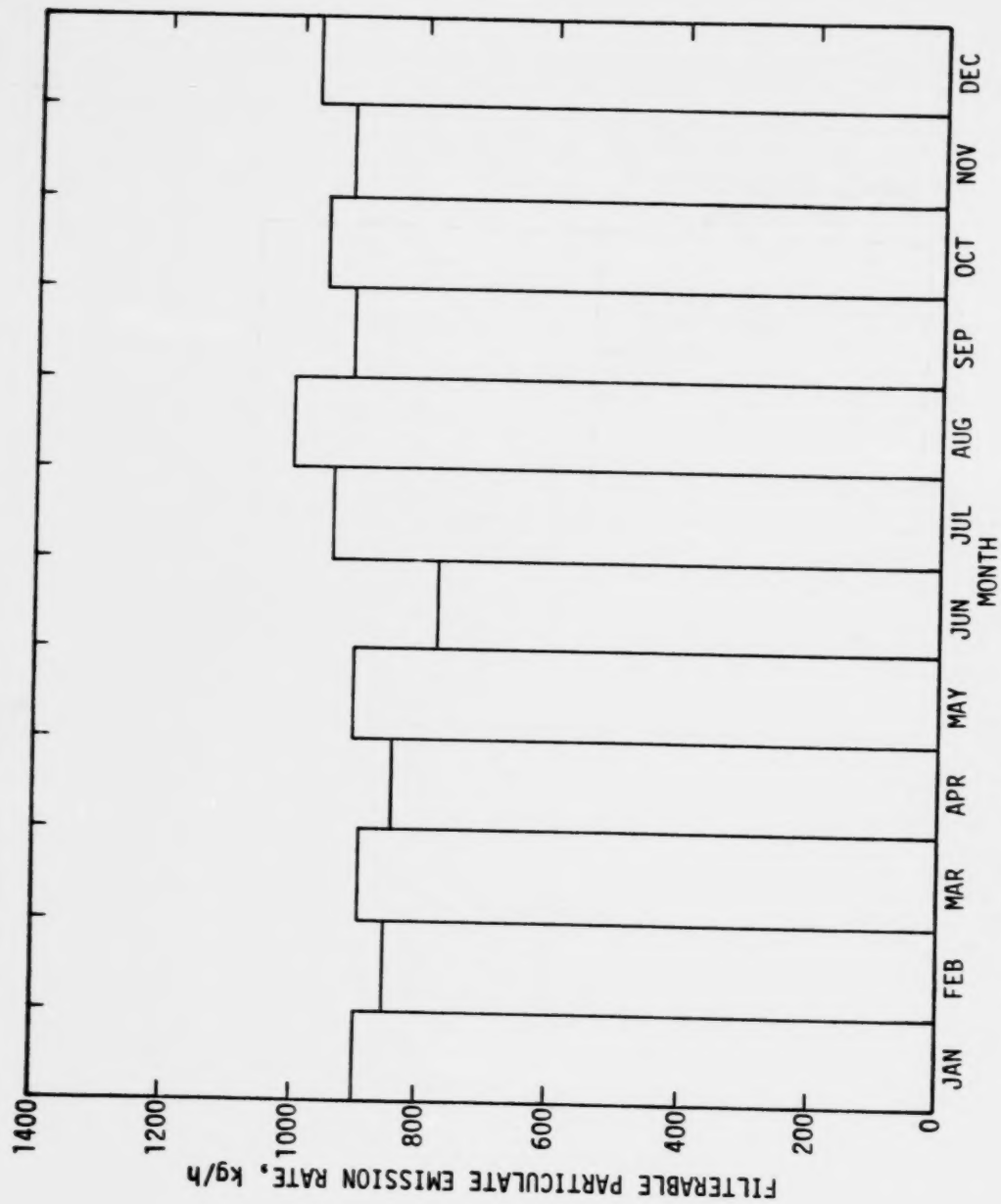


Figure 5-3. Group II - Monthly filterable particulate mass emissions.

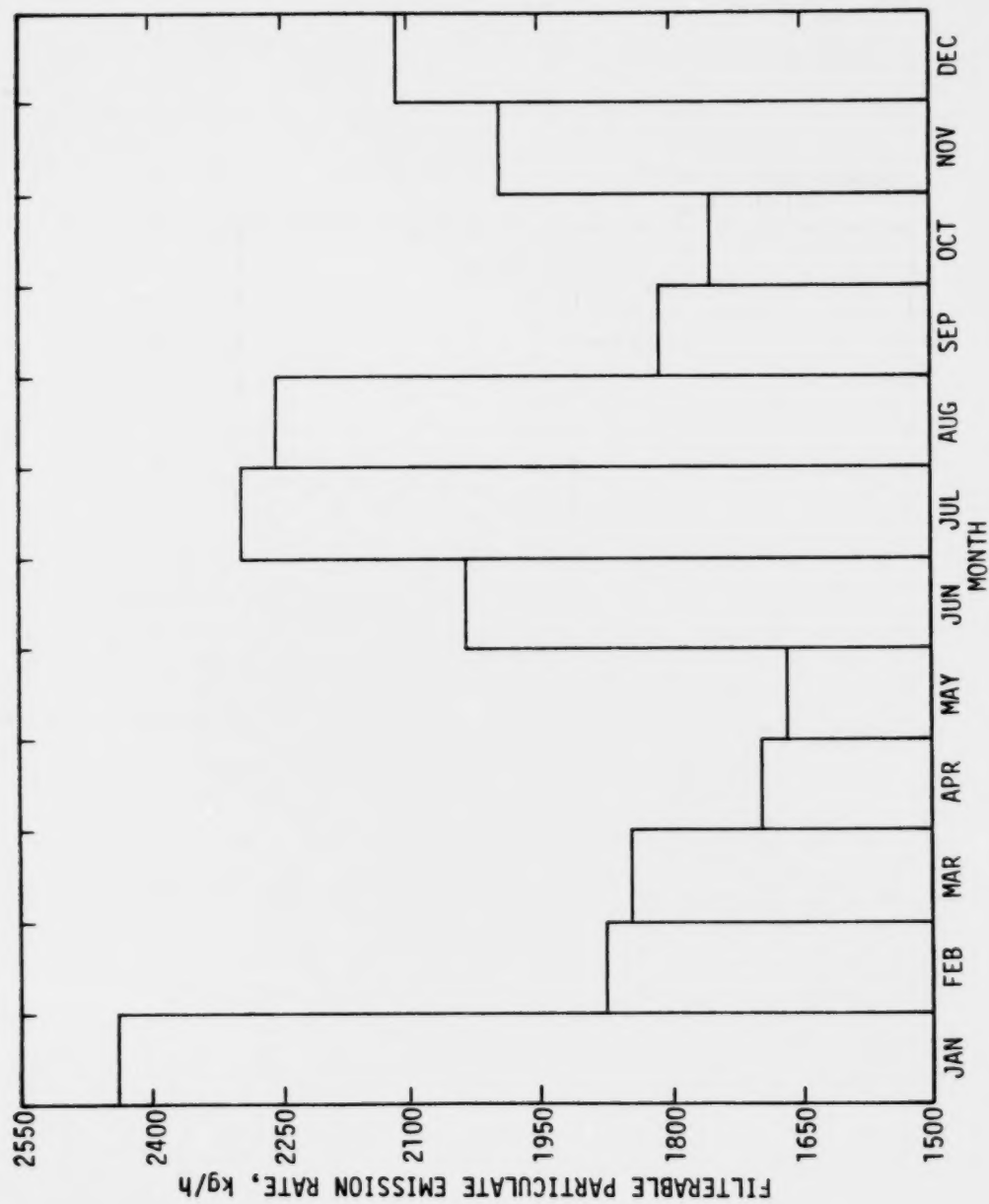


Figure 5-4. Group III - Monthly filterable particulate mass emissions.

SULFUR EMISSIONS

When determining particulate sulfate, gaseous SO_2 and H_2SO_4 mass emission rates for plants operating in the study region, the sulfur content (%S) and Higher Heating Value (HHV) of the coal being used had to be taken into account. The sulfur content of the coal being burned has a major effect on the amount of SO_2 and H_2SO_4 emissions as discussed previously. A relationship of the %S and HHV of the coals used at each plant tested to the %S and HHV of the coal used by other plants in the study region was used to approximate the projected SO_2 and H_2SO_4 emissions.

For power plants in Group II operating with an ESP as the only emissions control device the average emission factor from Plant B was used to calculate emission rates for particulate sulfate and gaseous H_2SO_4 . This was necessary since Plant C was not operating properly and the particulate sulfate emissions were higher than under normal operating conditions. The poor operating conditions also resulted in the gaseous H_2SO_4 emissions being much lower than expected. The reason for using the emission factor calculated for Plant B was that both Plants B and C burned the same type of coal.

SULFUR DIOXIDE

Tests at Plants A, B, and C showed that 96 percent of the sulfur contained in the coal was converted to sulfur dioxide. Also, the tests at Plants D and E indicated that the FGD systems removed 80 and 70 percent of sulfur dioxide at the respective

plants. This data along with the %S and HHV of the coal utilized at each plant was used to project the regional SO₂ yearly emissions.

The total yearly average SO₂ mass emission rate for all the power plants presently operating in the study region is 116,913 kg/h as shown in Figure 5-5. The SO₂ emission rates for each separate group are summarized in Tables 5-4 through 5-6. Figures 5-6 through 5-8 illustrate the monthly emissions for all the plants and for each group.

TABLE 5-4. GROUP I - MONTHLY SULFUR DIOXIDE MASS EMISSION RATE
EMISSION FACTOR = 892 mg/MJ
%S = 0.92
HHV = 12.17 MJ/lb

Plant	Unit/ size, MW	% S ¹	HHV, ² MJ/lb	Monthly sulfur dioxide emission rate, kg/h												Average sul- fur dioxide yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	3.40	11.55	865	670	580	1,007	396	122	0	115	0	14	163	490	368
	4/69	3.40	11.55	570	486	663	104	142	56	0	379	69	0	358	406	271
	5/71	3.40	11.55	684	0	184	31	0	0	97	656	73	0	63	24	149
Beckjord	6/71	3.40	11.55	462	0	59	0	261	80	28	584	104	0	0	24	132
	1/115	2.49	11.34	2,894	2,777	2,884	2,451	2,757	2,472	2,166	2,275	2,433	2,433	2,353	2,187	2,505
	2/112.5	2.49	11.34	2,360	2,399	2,513	2,301	2,176	2,197	1,925	1,957	2,070	2,138	1,368	1,106	2,042
Miami Fort	3/125	2.49	11.34	2,047	3,148	3,436	2,860	2,601	3,070	2,065	2,974	2,093	1,280	1,301	2,803	2,474
	5/100	2.08	11.99	43	948	1,183	536	1,505	1,171	344	0	0	716	991	819	688
Tanners Creek	1/150	0.6	12.63	500	555	605	618	466	0	456	450	387	662	508	593	483
	2/150	0.6	12.63	612	706	627	487	803	745	291	212	410	1,030	512	535	547
	3/215	0.6	12.63	1,191	1,047	769	766	1,167	900	747	650	71	792	654	753	845
Cane Run	1/112.5	3.5	11.37	4,831	4,188	2,546	2,764	2,383	679	0	2,423	781	0	320	138	1,754
	2/112.5	3.5	11.37	3,491	3,414	875	1,809	2,147	1,417	1,754	1,754	763	1,362	0	0	1,566
Total				20,549	20,339	16,924	15,736	16,804	12,907	9,874	14,427	9,254	10,427	8,589	9,879	13,824

¹ Average yearly sulfur content of coal reported by plants to the Department of Energy.
² Average yearly higher heating value of coal reported by plants to the Department of Energy.

TABLE 5-5. GROUP II - MONTHLY SULFUR DIOXIDE MASS EMISSION RATE

EMISSION FACTOR = 7351 mg/MJ

= 5762 mg/MJ

%S = 0.921

= 3.322

HHV = 12.17 MJ/lb

= 11.942 MJ/lb

Plant	Unit/ size, MW	% S ³	HHV, ⁴ MJ/lb	Monthly sulfur dioxide emission rate, kg/h												Average sul- fur dioxide yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	2.49	11.34	3,416	3,651	3,715	3,394	2,711	1,516	2,647	3,928	3,459	3,138	2,839	2,775	3,096
	5/244	2.49	11.34	3,544	4,078	5,316	4,910	5,636	3,693	3,480	3,800	3,864	4,633	3,459	4,291	4,227
Miami Fort	6/168	2.08	11.99	2,648	2,479	2,547	2,412	2,648	1,754	2,378	2,732	2,412	1,559	0	101	1,973
Clifty Creek	1/225	4.01	11.57	5,425	5,965	5,425	6,066	6,605	6,268	0	1,820	6,605	6,066	6,807	7,245	5,358
	2/225	4.01	11.57	6,066	6,167	5,526	6,605	2,595	202	6,504	6,505	7,043	7,346	6,942	7,245	5,729
	3/225	4.01	11.57	6,369	7,312	3,471	337	6,133	6,133	7,649	7,077	7,178	7,414	6,133	6,706	5,998
	4/225	4.01	11.57	2,527	0	4,852	6,099	7,380	6,841	6,436	5,257	6,335	5,493	6,841	5,796	5,324
	5/225	4.01	11.57	7,110	6,773	7,211	6,773	7,211	6,436	6,874	6,672	6,571	7,110	5,493	7,110	6,773
	6/225	4.01	11.57	6,066	5,425	7,144	6,908	7,245	6,706	6,706	4,583	0	4,145	6,908	6,268	5,762
Gallagher	1/150	3.4	11.68	509	0	0	0	0	85	1,698	2,179	2,094	2,009	1,528	1,783	991
	2/150	3.4	11.68	1,189	2,887	2,887	2,660	2,123	2,491	2,660	1,783	2,038	2,208	1,953	2,208	2,264
	3/150	3.4	11.68	3,057	2,717	2,462	2,717	2,123	0	934	2,123	2,123	2,462	2,632	2,462	2,151
	4/150	3.4	11.68	2,462	170	0	0	680	2,038	2,462	2,377	2,038	1,698	2,293	2,377	1,557
Cane Run	3/147	3.5	11.37	3,173	3,202	2,095	1,945	2,394	1,437	1,018	2,425	1,915	539	1,227	1,257	1,886
	4/178	3.5	11.37	0	0	0	0	0	396	1,417	1,557	345	546	906	740	491
	5/183	3.5	11.37	747	619	721	434	313	721	174	734	542	702	1,098	625	600
Total				54,308	51,454	53,374	51,262	55,796	46,716	53,007	55,550	54,561	57,067	57,058	58,989	54,180

¹This value used for power plants using an ESP as their only emission control device.²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.³Average yearly sulfur content of coal reported by plants to the Department of Energy.⁴Average yearly higher heating value of coal reported by plants to the Department of Energy.

TABLE 5-6. GROUP III - MONTHLY SULFUR DIOXIDE MASS EMISSION RATE

EMISSION FACTOR = 6831 mg/MJ
 = 9052 mg/MJ
 %S = 1.031
 = 3.502
 HHV = 12.261 MJ/lb
 = 11.162 MJ/lb

Plant	Unit/ size, MW	% S ³	HHV, ⁴ MJ/lb	Monthly sulfur dioxide emission rate, kg/h												Average sul- fur dioxide yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	2.49	11.34	4,445	0	0	0	982	2,874	5,534	5,695	2,232	6,391	6,337	4,070	3,213
Stuart	1/610	1.2	11.79	4,245	3,327	3,740	3,053	513	3,732	3,782	4,137	1,547	4,635	2,979	4,328	3,335
	2/610	1.2	11.79	3,302	2,656	3,128	4,154	2,507	3,856	4,080	3,649	2,094	4,179	4,030	3,260	3,409
	3/610	1.2	11.79	3,302	3,062	3,269	1,489	4,046	3,128	3,831	3,674	3,120	3,368	2,408	3,922	3,219
	4/610	1.2	11.79	4,220	3,252	3,542	1,365	4,336	3,095	4,146	4,079	4,005	1,175	4,005	4,195	3,451
Miami Fort	7/500	2.08	11.99	5,021	2,553	5,768	5,331	3,963	4,203	5,627	4,640	4,894	2,553	6,163	6,474	4,767
	8/500	2.08	11.99	5,613	4,640	733	4,852	4,725	4,344	4,005	4,288	4,809	4,711	629	0	3,611
Tanners Creek	4/500	3.7	11.24	8,912	5,807	5,995	6,557	2,141	7,012	10,598	8,698	7,039	3,051	11,106	10,464	7,279
Ghent	1/511	2.1	12.28	5,756	5,589	5,061	3,865	5,089	6,215	5,909	6,326	1,349	4,157	6,395	6,354	5,172
	2/511	2.1	12.28	7,814	5,825	3,657	3,796	2,489	806	2,975	2,628	4,755	1,098	1,001	3,351	3,409
Cane Run	6/277	3.5	11.37	1,680	1,106	1,276	1,147	1,421	1,381	1,252	1,502	1,155	509	1,155	1,639	1,268
Mill Creek	1/335	3.7	11.47	1,980	592	0	685	1,980	2,082	186	1,726	1,633	1,219	2,133	2,039	1,472
	2/326	3.7	11.47	2,327	1,989	1,963	1,853	1,041	1,752	1,921	1,295	1,905	1,828	2,166	1,794	1,819
	3/425	3.7	11.47	1,017	2,691	3,239	2,353	2,023	2,920	3,013	2,369	2,835	2,674	178	0	2,107
Spurlock	1/300	1.23	11.97	1,930	1,830	1,804	1,420	969	1,387	1,529	1,487	1,311	0	1,370	1,495	1,378
Total				61,562	44,919	43,185	41,920	38,225	48,787	58,388	56,193	14,683	41,548	52,056	43,386	48,909

- ¹This value used for power plants using an ESP as their only emission control device.
- ²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.
- ³Average yearly sulfur content of coal reported by plants to the Department of Energy.
- ⁴Average yearly higher heating value of coal reported by plants to the Department of Energy.

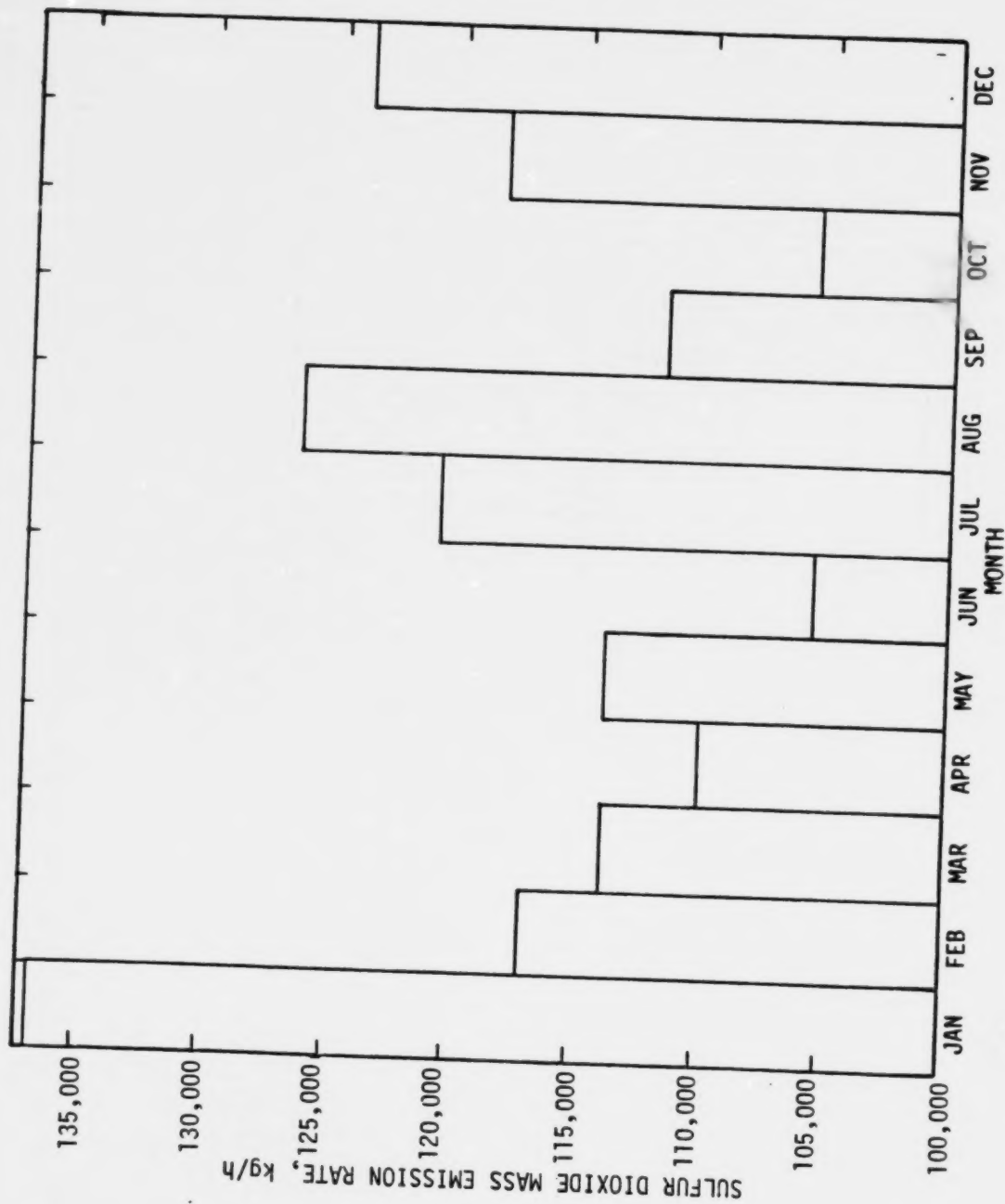


Figure 5-5. Total monthly sulfur dioxide mass emissions.

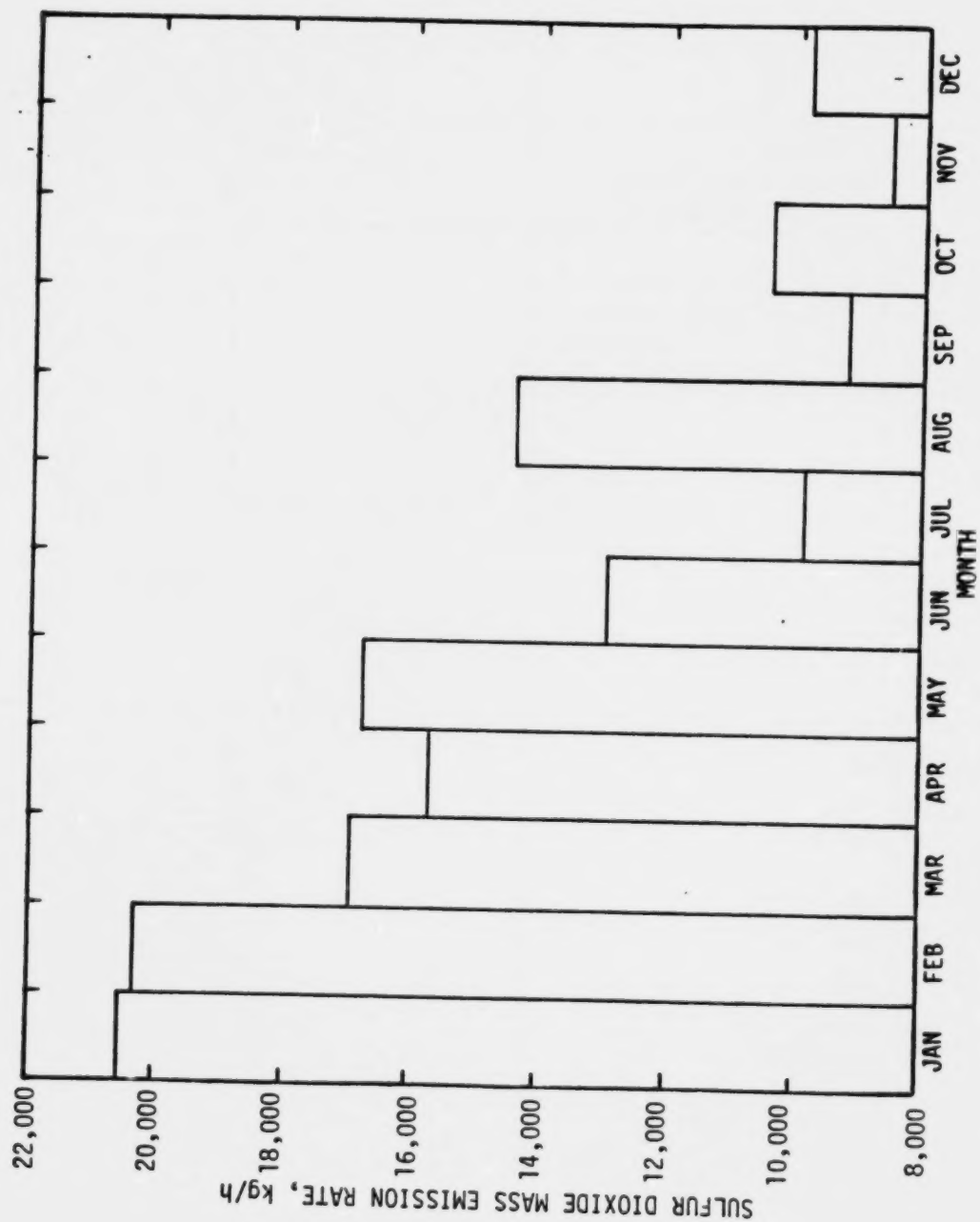


Figure 5-6. Group I monthly sulfur dioxide mass emissions.

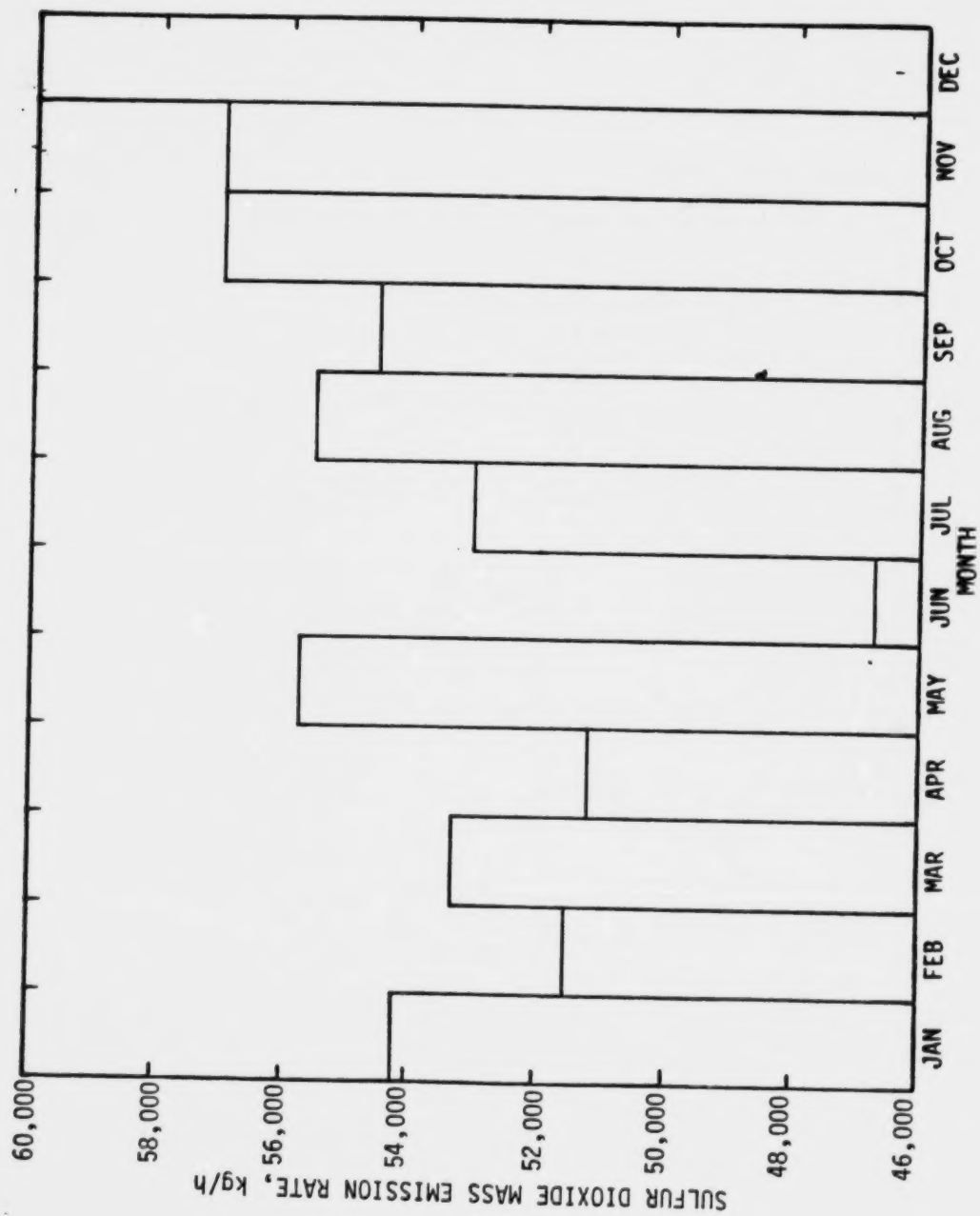


Figure 5-7. Group II monthly sulfur dioxide mass emissions.

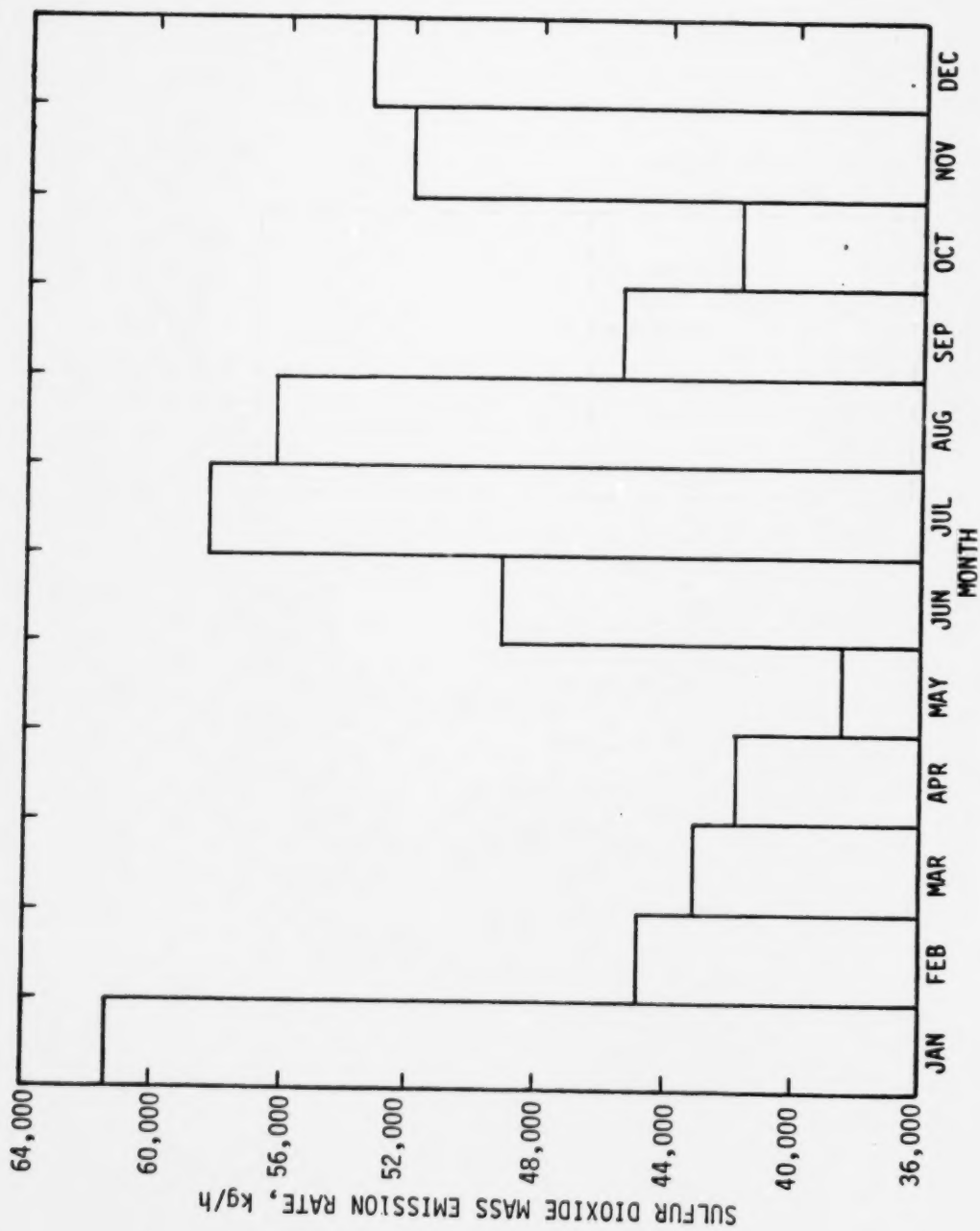


Figure 5-8. Group III monthly sulfur dioxide mass emissions.

SULFURIC ACID MIST

Sulfuric acid mist regional emissions are based on the percent sulfur in the coal and the type of control equipment utilized by the plant. The total yearly average H_2SO_4 mass emission rate for all the power plants operating in the study region is 757 kg/h as shown in Figure 5-9. The yearly average H_2SO_4 emission rate for plants in Group I is 74 kg/h, Group II is 381 kg/h, and Group III is 302 kg/h. Tables 5-7 through 5-9 summarize this data. Figures 5-10 through 5-12 illustrate the yearly emissions of H_2SO_4 on a monthly basis.

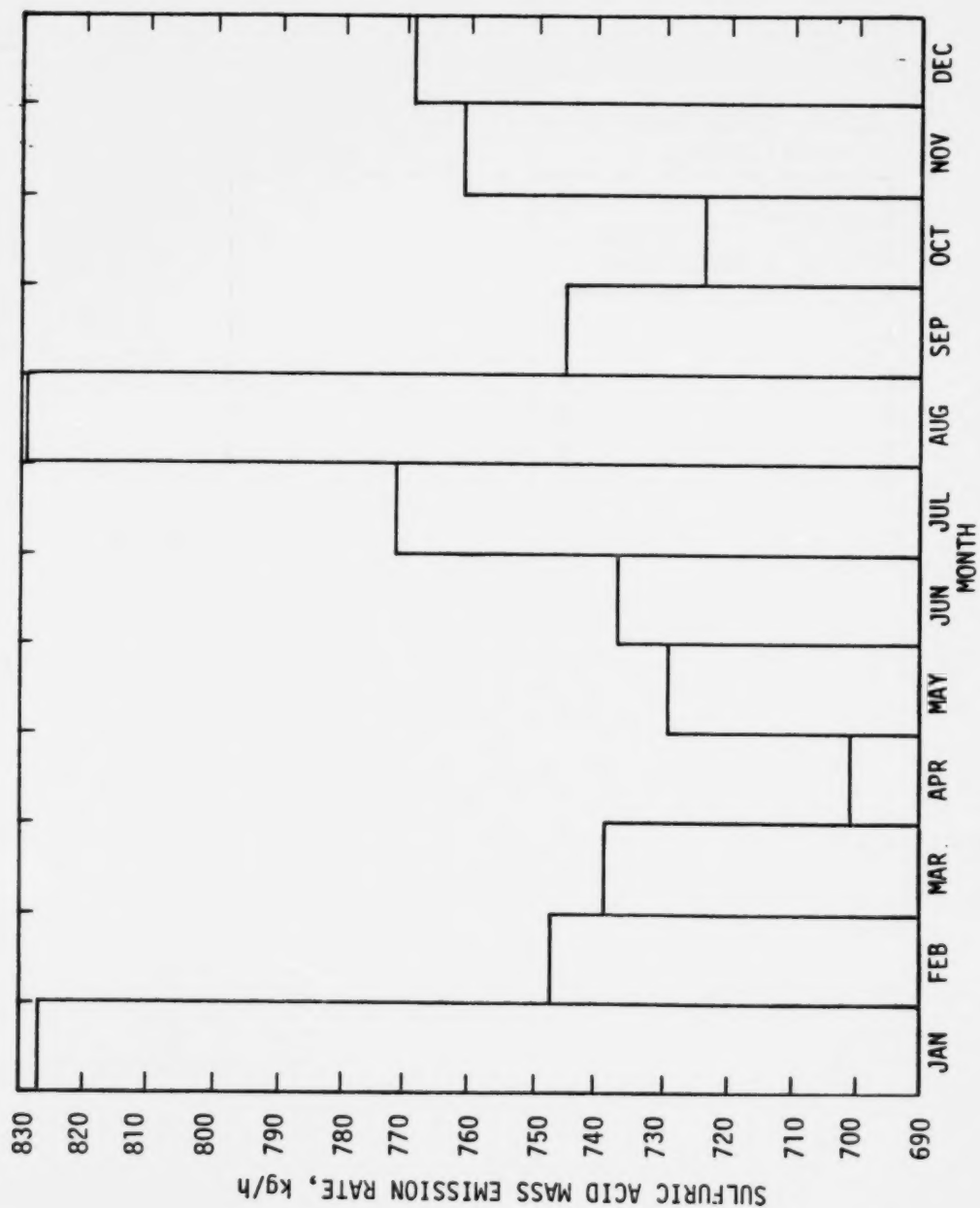


Figure 5-9. Total sulfuric acid mist mass emissions from Groups I, II, and III.

TABLE 5-7. GROUP I - MONTHLY SULFURIC ACID MASS EMISSION RATE
EMISSION FACTOR = 4.84 mg/MJ
% S = 0.92
HHV = 12.17 MJ/lb

Plant	Unit/ size, MW	S ¹	HHV, ² MJ/lb	Monthly H ₂ SO ₄ emission rates, kg/h												Average H ₂ SO ₄ yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	3.40	11.55	4.70	3.65	3.16	5.48	2.16	2.56	0.00	0.64	0.00	0.08	0.89	2.66	2.16
	4/69	3.40	11.55	3.09	2.65	3.61	0.58	0.79	0.31	0.00	2.07	0.39	0.00	1.95	2.22	1.47
	5/71	3.40	11.55	3.72	0.00	1.00	0.17	0.00	0.00	0.53	3.57	0.40	0.00	0.35	0.14	0.82
Beckjord	6/71	3.40	11.55	2.51	0.00	0.33	0.00	1.43	0.44	0.17	3.17	0.58	0.00	0.00	0.14	0.88
	1/115	2.49	11.34	1.66	15.07	15.66	13.31	14.96	13.41	11.76	12.35	13.20	13.20	12.77	11.86	13.38
	2/112.5	2.49	11.34	12.81	13.02	13.65	12.50	11.82	11.92	10.46	10.62	11.24	11.61	7.42	6.01	11.09
Mani Fort	3/125	2.49	11.34	11.11	17.08	18.64	15.53	14.12	16.67	11.22	16.15	11.37	1.33	7.06	15.21	12.96
	5/100	2.08	11.99	0.24	5.14	6.43	2.92	8.17	6.36	1.88	0.00	0.00	3.89	5.39	4.45	3.74
	1/150	0.6	12.63	2.72	3.01	3.29	3.36	2.53	0.00	0.96	2.44	2.10	3.59	2.76	3.22	2.50
Tanner Creek	2/150	0.6	12.63	3.32	3.83	3.40	2.64	4.36	4.04	1.58	1.15	2.22	5.59	2.78	2.90	3.15
	3/215	0.6	12.63	6.46	5.68	4.17	4.16	6.33	4.88	4.05	3.53	3.84	4.30	3.55	4.09	4.59
	1/112.5	3.5	11.37	26.22	22.78	13.92	15.01	12.95	3.70	0.00	13.16	4.24	0.00	1.74	0.76	9.53
Cane Run	2/112.5	3.5	11.37	18.95	18.54	4.76	9.83	11.65	7.70	8.54	9.52	4.15	7.40	0.00	0.00	8.42
				97.51	110.45	91.92	85.49	91.27	71.99	51.15	78.37	53.73	50.99	46.66	53.66	73.59
Total																

¹ Average yearly sulfur content of coal reported by plants to the Department of Energy.

² Average yearly higher heating value of coal reported by plants to the Department of Energy.



Reproduced from
best available copy.

TABLE 5-8. GROUP II - MONTHLY SULFURIC ACID MASS EMISSION RATE

EMISSION FACTOR = 4.841 mg/MJ
 = 16.822 mg/MJ
 % S = 0.921
 = 3.322
 HHV = 12.171
 = 11.942

Plant	Unit/ Size, MW	% S ³	HHV, ⁴ MJ/lb	Monthly H ₂ SO ₄ emission rates, kg/h												Average H ₂ SO ₄ yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	2.49	11.34	22.70	24.04	24.46	22.35	17.35	9.93	17.43	25.87	22.77	20.66	18.70	18.28	20.40
	5/224	2.49	11.34	23.34	26.85	35.00	32.33	37.11	24.32	22.92	25.02	25.44	30.51	22.77	28.25	27.82
Miami Fort	6/168	2.08	11.99	17.44	16.33	16.77	15.88	17.44	11.55	15.66	17.99	15.88	10.33	0.00	0.67	13.00
	1/225	4.01	11.57	35.73	39.23	35.73	39.94	43.49	41.27	0.00	11.98	43.49	39.94	44.82	47.71	35.28
Clifty Creek	2/225	4.01	11.57	39.94	40.61	36.39	43.49	17.99	1.33	42.83	42.83	46.38	48.37	45.71	47.71	37.72
	3/225	4.01	11.57	41.94	48.15	22.96	2.22	40.38	40.38	50.37	46.60	47.26	48.82	40.38	44.16	39.46
	4/225	4.01	11.57	16.64	0.00	31.95	40.16	48.60	45.04	42.38	34.62	41.72	36.17	45.04	38.17	35.04
	5/225	4.01	11.57	46.82	44.60	47.49	44.60	47.49	42.38	45.27	43.94	43.27	46.82	36.17	46.82	44.64
Gallagher	6/225	4.01	11.57	39.94	35.73	47.04	45.49	47.71	44.16	44.16	30.18	0.00	27.29	45.49	41.27	37.37
	1/150	3.4	11.68	3.35	0.00	0.00	0.00	0.00	0.56	11.18	14.35	13.79	13.23	10.06	11.74	6.52
	2/150	3.4	11.68	7.83	19.01	19.01	17.52	13.93	16.40	17.52	11.74	13.42	14.54	12.86	14.54	14.86
	3/150	3.4	11.68	20.13	17.99	16.21	17.89	13.93	0.0	6.15	13.98	13.93	16.21	17.33	16.21	14.16
Cane Run	4/150	3.4	11.68	16.21	1.12	0.00	0.00	4.47	13.42	16.21	15.66	13.42	11.18	15.10	15.66	10.20
	3/147	3.5	11.37	20.89	21.09	13.80	12.91	15.77	9.46	6.70	15.96	12.61	3.55	8.08	8.28	12.42
	4/178	3.5	11.37	0.00	0.00	0.00	0.00	0.00	11.06	39.62	43.54	9.64	14.99	25.34	20.70	13.74
	5/183	3.5	11.37	20.88	17.31	20.16	12.14	8.74	20.16	17.84	20.52	15.17	19.63	30.69	17.49	18.39
Total				373.57	352.01	366.87	346.92	374.10	331.47	306.24	414.78	378.24	402.24	418.54	417.66	381.02

¹ This value used for power plants using an ESP as their only emission control device.

² This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

³ Average yearly sulfur content of coal reported by plants to the Department of Energy.

⁴ Average yearly higher heating value of coal reported by plants to the Department of Energy.

TABLE 5-9. GROUP III - MONTHLY SULFURIC ACID MASS EMISSION RATE

EMISSION FACTOR = 2.401 mg/MJ
 = 19.312 mg/MJ
 % S = 1.031
 = 3.502
 HHV = 12.261
 = 11.162

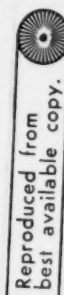
Plant	Unit/ size, MW	% S ³	HHV, 4 MJ/lb	Monthly H ₂ SO ₄ emission rates, kg/h												Average H ₂ SO ₄ yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	2.49	11.34	15.62	0.00	0.00	0.00	3.45	10.10	19.44	20.01	7.84	22.46	22.27	14.30	11.29
Stuart	1/610	1.2	11.79	14.92	11.69	13.14	10.73	1.80	13.11	13.29	14.54	5.44	16.28	10.47	15.21	11.72
	2/610	1.2	11.79	11.60	9.33	10.99	14.60	8.81	13.55	14.33	12.82	7.36	14.68	14.16	11.46	11.97
	3/610	1.2	11.79	11.60	10.76	11.43	5.23	14.22	10.99	13.46	12.91	10.96	11.83	8.46	13.78	11.31
	4/610	1.2	11.79	14.83	11.43	12.44	4.80	15.24	10.87	14.57	14.33	14.07	4.13	14.07	14.74	12.13
Miami Fort	7/500	2.08	11.99	17.64	8.97	20.27	13.73	13.92	14.77	19.77	16.30	17.20	8.97	21.66	22.75	16.74
	8/500	2.08	11.99	19.72	16.30	2.58	17.05	16.60	15.26	14.07	15.06	16.90	16.55	2.18	0.00	12.69
Tanners Creek	4/500	3.7	11.24	31.31	20.41	21.06	23.04	7.52	24.64	37.24	30.56	24.73	10.72	39.02	36.77	25.58
	1/511	2.1	12.28	20.22	19.64	17.78	13.59	17.88	21.84	20.76	22.23	4.74	14.61	22.47	22.32	18.17
Ghent	2/511	2.1	12.28	27.46	20.47	12.85	13.34	8.74	2.83	10.45	9.23	16.71	3.86	3.52	11.77	11.77
Cane Run	6/277	3.5	11.37	39.42	25.97	29.95	26.91	35.36	32.41	29.38	35.25	27.10	11.94	27.10	38.45	29.77
	1/335	3.7	11.47	46.48	13.90	0.00	16.09	46.48	48.86	4.37	40.52	38.33	28.60	50.05	47.87	31.80
Mill Creek	2/326	3.7	11.47	54.62	46.68	46.08	41.50	24.43	41.11	45.09	30.39	44.69	42.90	50.85	42.11	42.70
	3/425	3.7	11.47	23.83	63.16	75.67	55.22	47.47	68.52	70.71	55.61	66.54	62.76	4.17	0.00	49.47
Spurlock	1/300	1.23	11.97	6.73	6.43	6.34	4.99	3.41	4.87	5.37	5.23	9.83	0.00	4.81	5.25	5.28
Total				356.05	285.14	280.63	267.81	263.33	333.73	323.30	334.99	312.44	270.29	295.26	296.81	302.39

¹This value used for power plants using an ESP as their only emission control device.

²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

³Average yearly sulfur content of coal reported by plants to the Department of Energy.

⁴Average yearly higher heating value of coal reported by plants to the Department of Energy.



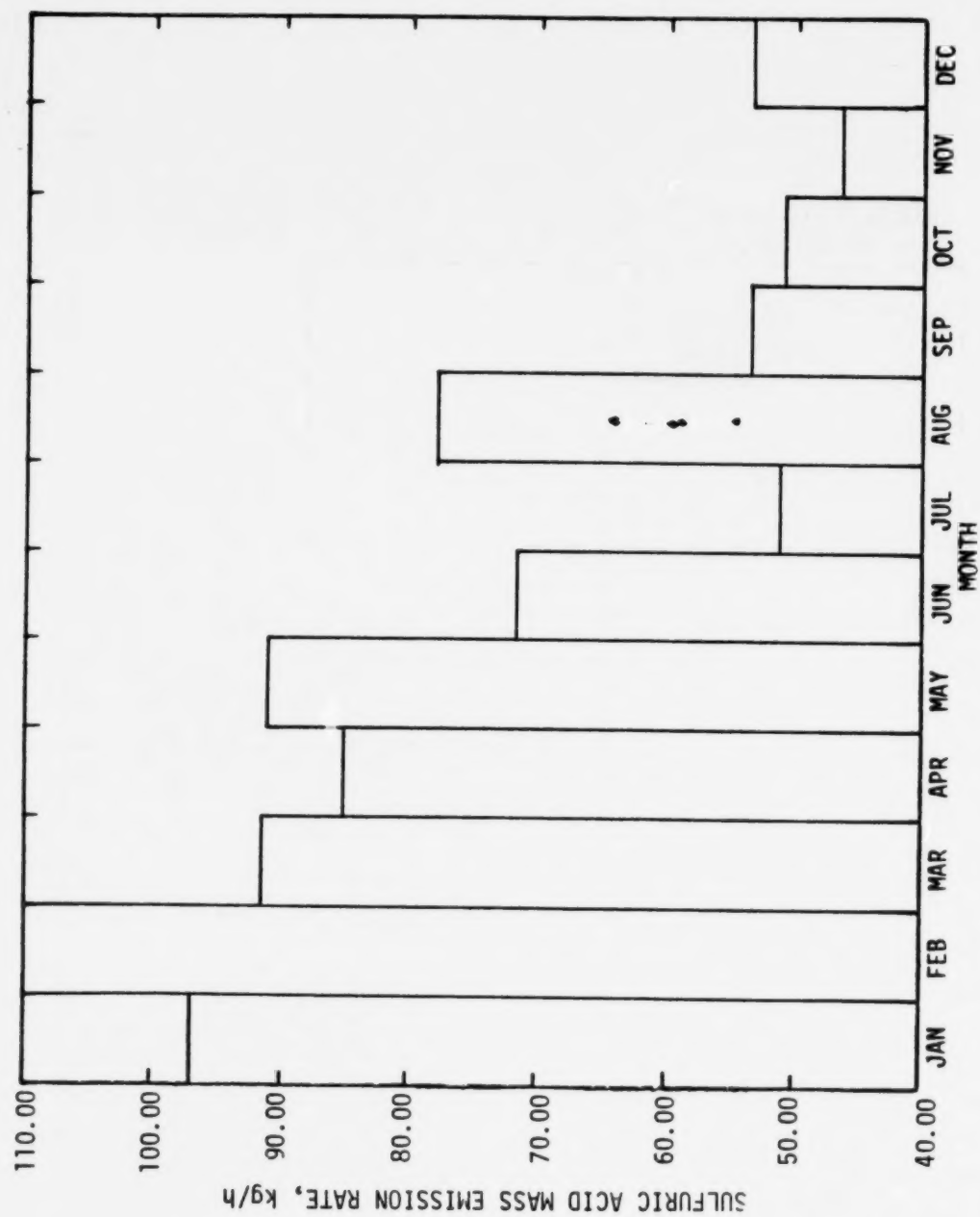


Figure 5-10. Group I monthly sulfuric acid mist mass emissions.

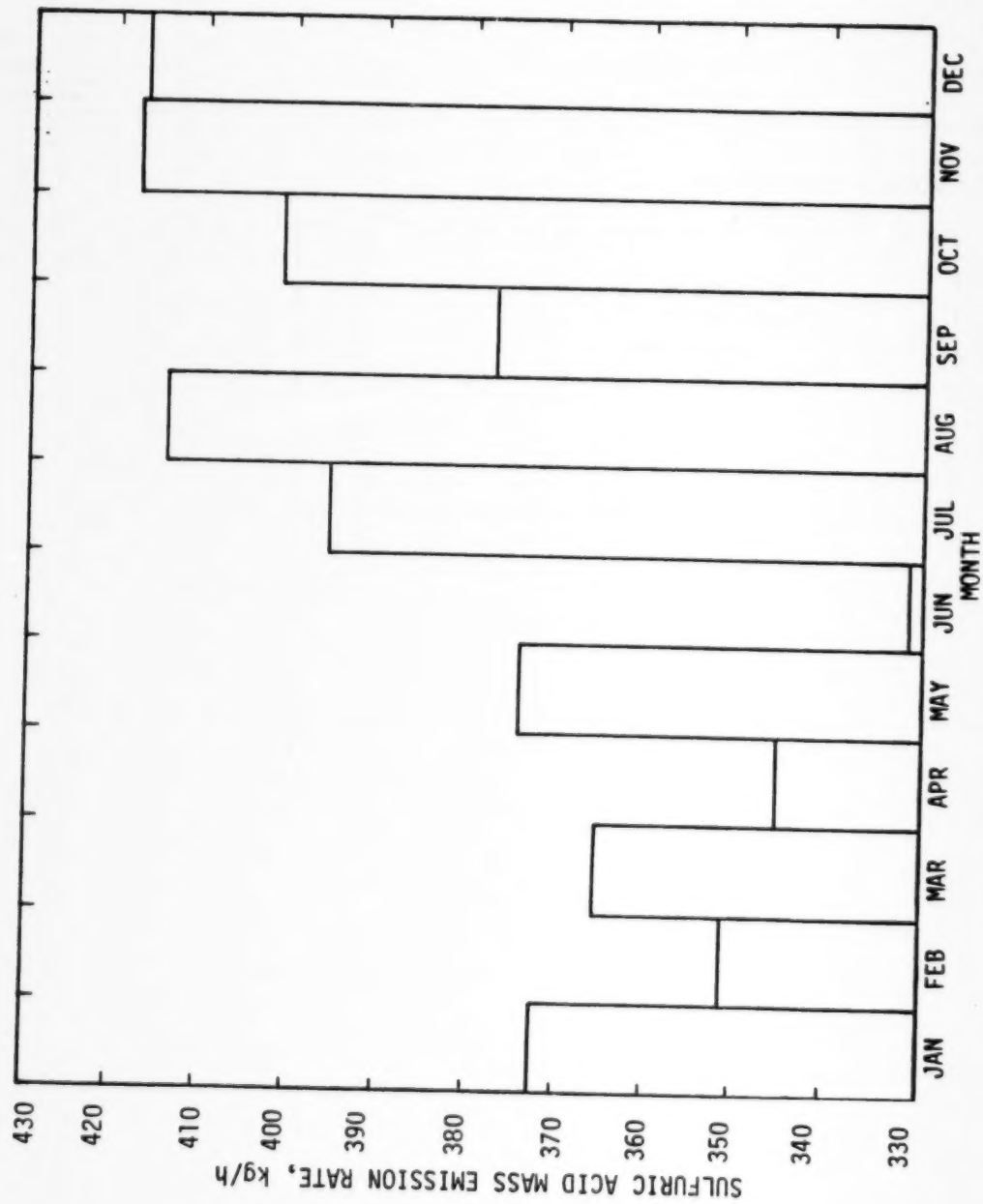


Figure 5-11. Group II monthly sulfuric acid mist mass emissions.

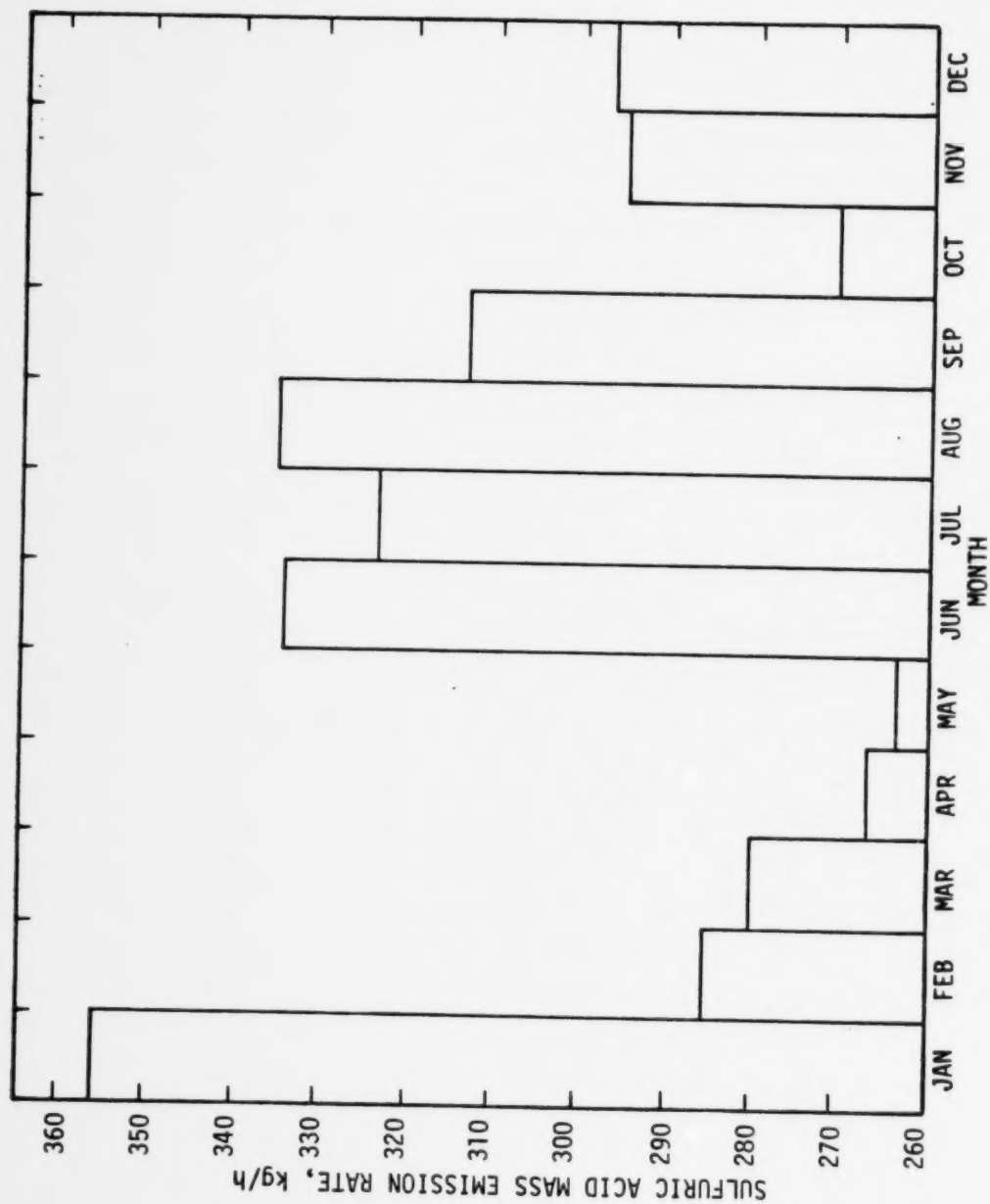


Figure 5-12. Group III monthly sulfuric acid mist mass emissions.

PARTICULATE SULFATE EMISSIONS

Compared to the sulfur dioxide and H_2SO_4 emissions, regional emissions of particulate sulfate seem insignificant. The total yearly average particulate sulfate mass emission rate for all the power plants presently operating in the region is 15.8 kg/h as shown in Figure 5-13. The yearly average particulate sulfate emissions from Group I is 1.3 kg/h, Group II is 6.2, and Group III is 8.3 kg/h. Figures 5-14 through 5-16 and Tables 5-10 through 5-12 present these data.

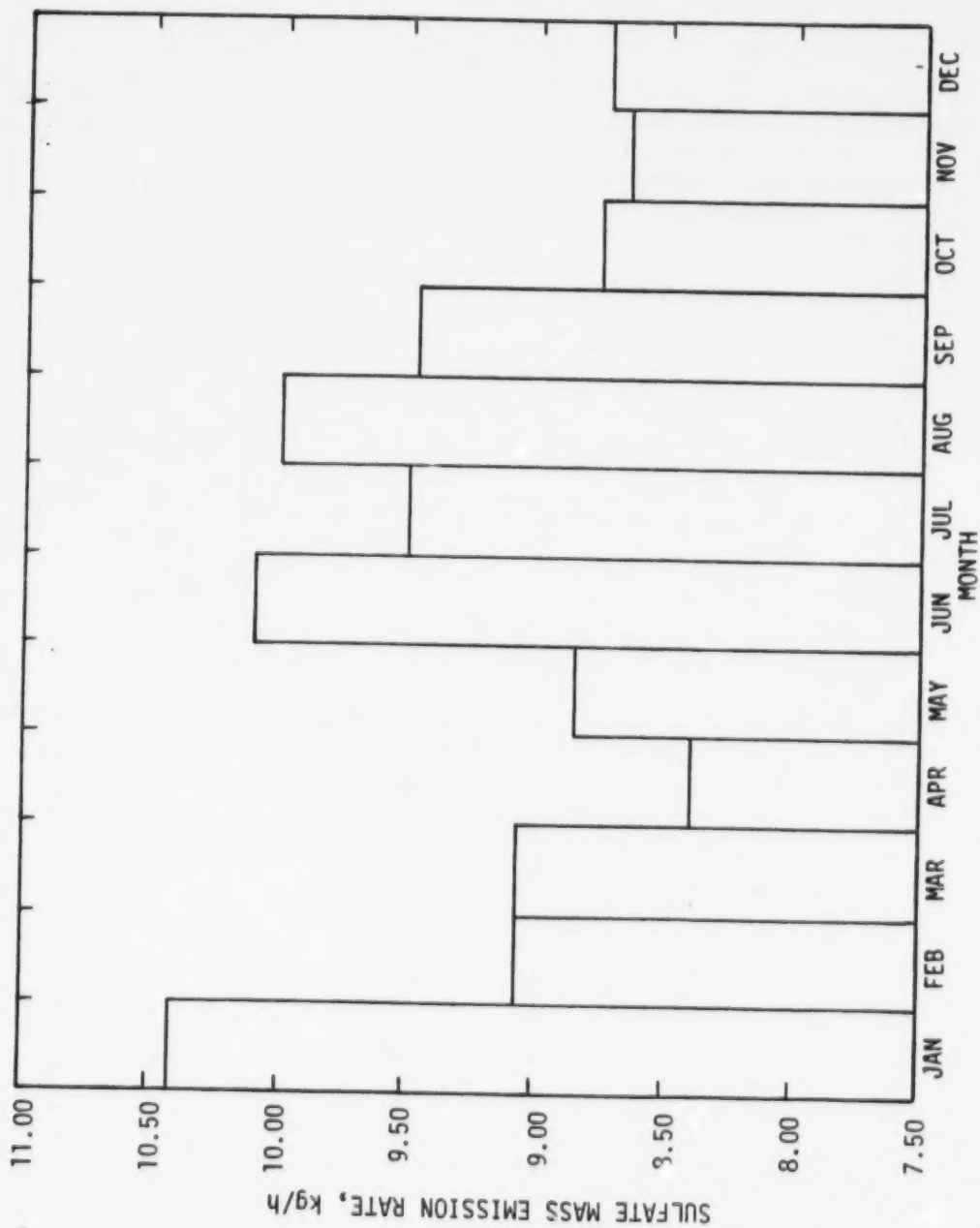


Figure 5-13. Total sulfate mass emissions.

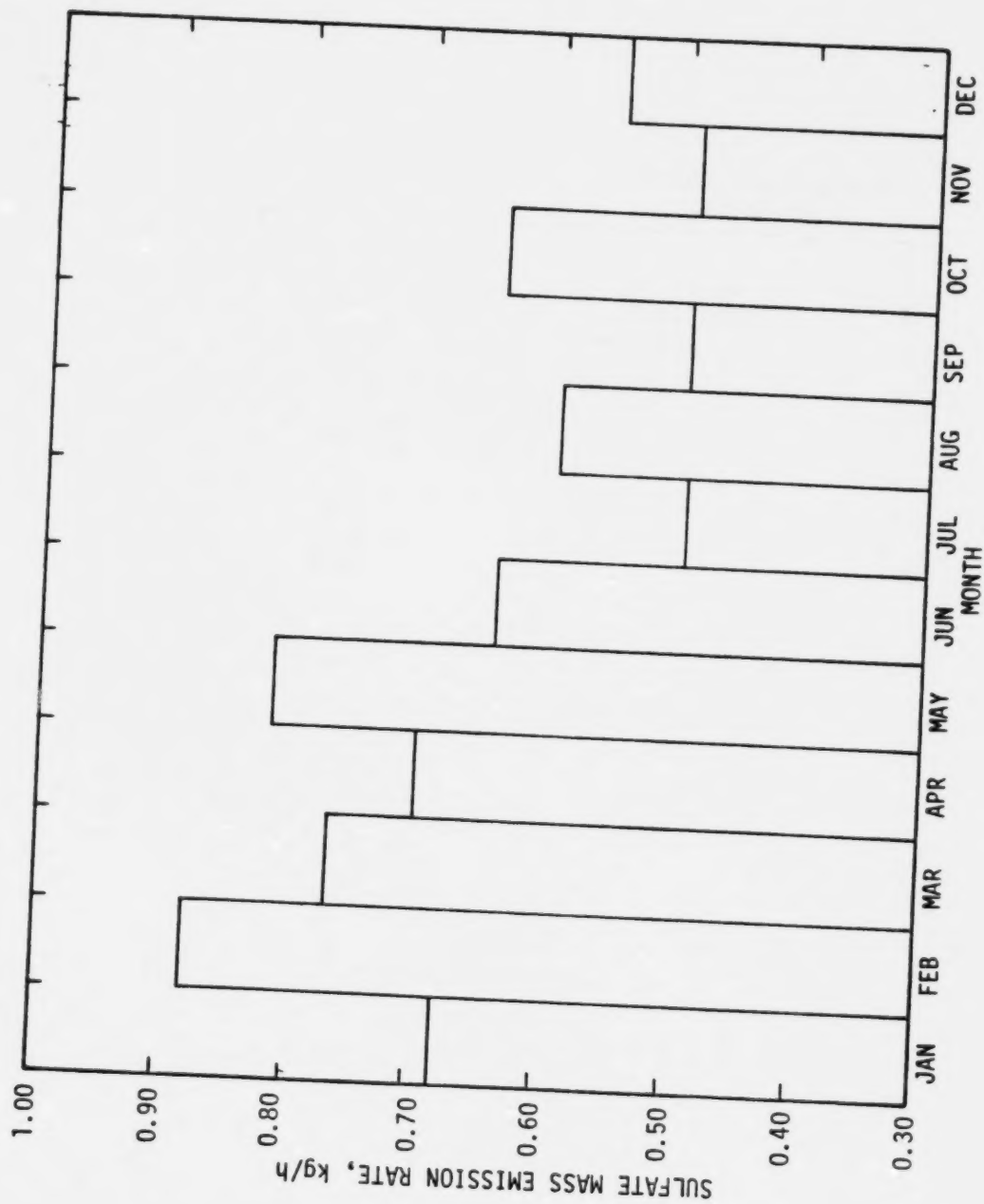


Figure 5-14. Group I monthly sulfate mass emissions.

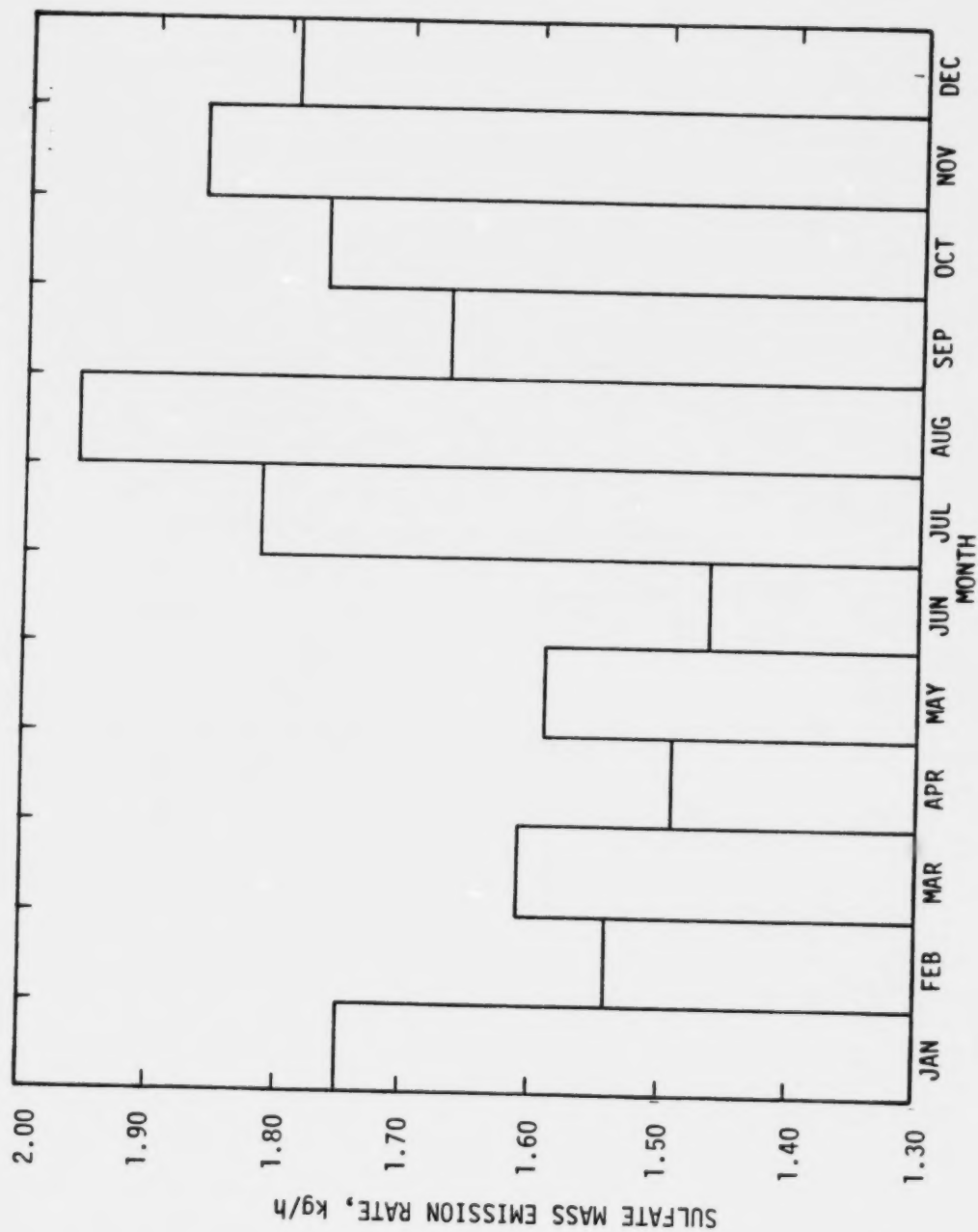


Figure 5-15. Group II monthly sulfate mass emissions.

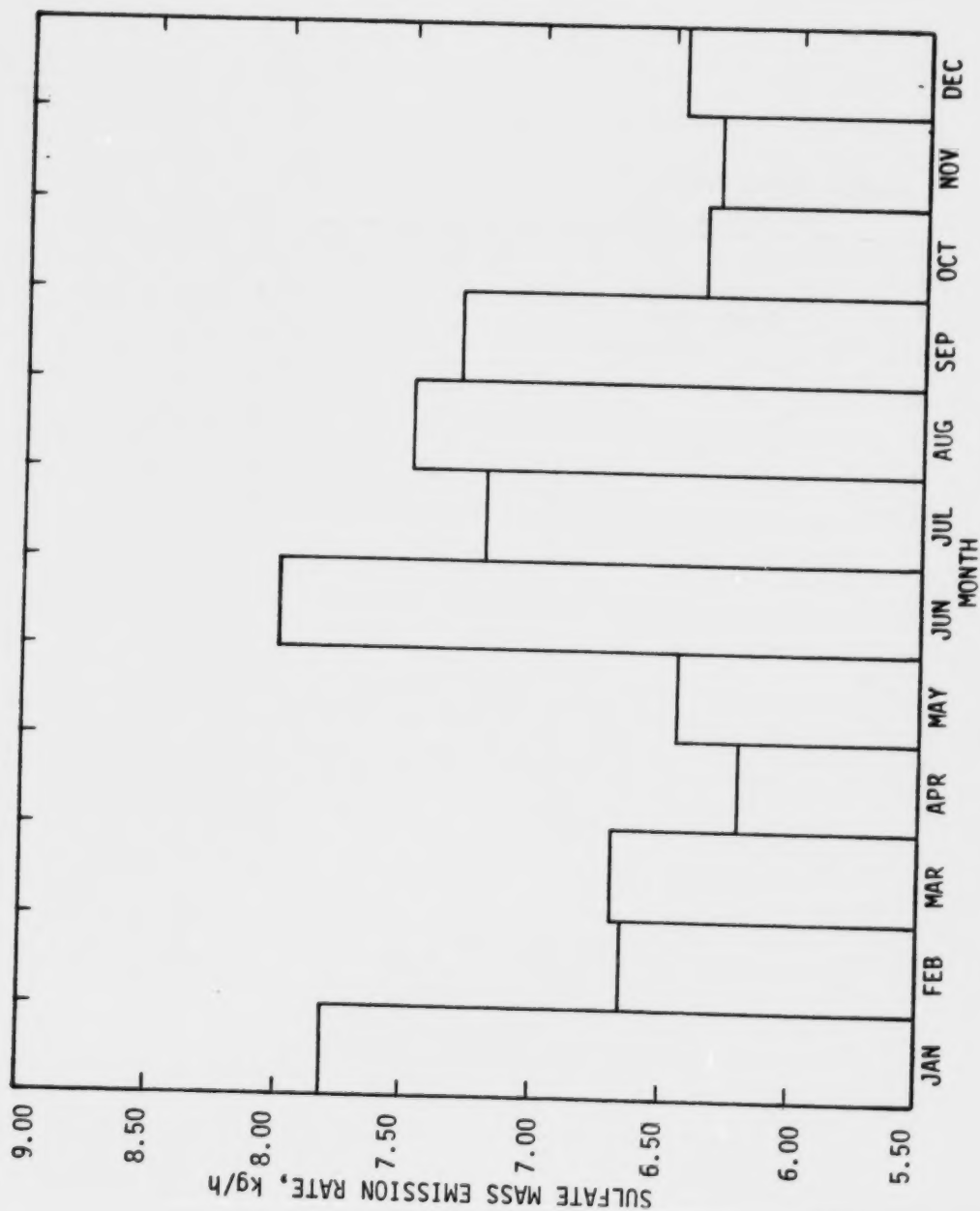


Figure 5-16. Group III monthly sulfate mass emissions.

TABLE 5-10. GROUP I - MONTHLY SULFATE MASS EMISSION RATE
EMISSION CONSTANT = 0.086 mg/MJ
% S = 0.92
HHV = 12.7 MJ/lb

Plant	Unit/ size, MW	% S ¹	HHV, ² MJ/lb	Monthly sulfate emission rate, kg/h												Average sulfate yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	3.40	11.55	0.082	0.066	0.054	0.097	0.039	0.047	0.000	0.012	0.000	0.000	0.016	0.047	0.035
	4/69	3.40	11.55	0.054	0.047	0.066	0.012	0.016	0.004	0.000	0.035	0.008	0.000	0.035	0.039	0.027
	5/71	3.40	11.55	0.066	0.000	0.019	0.004	0.000	0.000	0.008	0.062	0.008	0.000	0.008	0.004	0.016
	6/71	3.40	11.55	0.043	0.000	0.008	0.000	0.027	0.008	0.004	0.058	0.012	0.000	0.000	0.004	0.012
Beckjord	1/115	2.49	11.34	0.278	0.267	0.278	0.235	0.267	0.238	0.209	0.220	0.235	0.235	0.226	0.212	0.241
	2/112.5	2.49	11.34	0.226	0.232	0.244	0.223	0.209	0.212	0.186	0.189	0.200	0.206	0.131	0.107	0.197
	3/125	2.49	11.34	0.197	0.305	0.331	0.276	0.249	0.296	0.200	0.287	0.203	0.125	0.125	0.270	0.238
Miami Fort	5/100	2.08	11.99	0.005	0.096	0.114	0.053	0.144	0.112	0.034	0.000	0.000	0.069	0.096	0.078	0.066
Tanners Creek	1/150	0.6	12.63	0.049	0.054	0.059	0.060	0.045	0.000	0.044	0.043	0.037	0.064	0.049	0.057	0.047
	2/150	0.6	12.63	0.059	0.068	0.060	0.047	0.077	0.083	0.028	0.021	0.040	0.037	0.050	0.052	0.053
	3/150	0.6	12.63	0.118	0.101	0.074	0.074	0.113	0.087	0.072	0.063	0.069	0.077	0.063	0.073	0.082
Cane Run	1/122.5	3.5	11.37	0.464	0.403	0.256	0.269	0.232	0.065	0.000	0.232	0.077	0.000	0.033	0.012	0.171
	2/112.5	3.5	11.37	0.338	0.330	0.085	0.175	0.208	0.138	0.171	0.071	0.073	0.130	0.000	0.000	0.151
Total				1.969	1.648	1.525	1.626	1.290	0.956	1.393	0.943	0.832	0.955			1.336

¹ Average yearly sulfur content of coal reported by plants to the Department of Energy.

² Average yearly higher heating value of coal reported by plants to the Department of Energy.

TABLE 5-11. GROUP II - MONTHLY SULFATE MASS EMISSION RATE
EMISSION CONSTANT = 0.1137 mg/MJ
= 0.082 mg/MJ
%S = 0.921
= 3.322
HHV = 12.171
= 11.942

Plant	Unit/ size, MW	% S ¹	HHV, ² MJ/lb	Monthly sulfate emission rate, kg/h												Average sulfate yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	2.49	11.34	0.377	0.406	0.406	0.377	0.290	0.165	0.287	0.435	0.377	0.348	0.319	0.290	0.348
	5/244	2.49	11.34	0.377	0.435	0.580	0.522	0.609	0.407	0.377	0.406	0.435	0.493	0.377	0.464	0.464
Miami Fort	6/168	2.08	11.99	0.298	0.275	0.275	0.252	0.298	0.190	0.252	0.298	0.252	0.172	0.000	0.011	0.215
	1/225	4.01	11.57	0.611	0.658	0.611	0.658	0.752	0.705	0.000	0.202	0.752	0.658	0.752	0.799	0.611
Clifty Creek	2/225	4.01	11.57	0.658	0.705	0.611	0.752	0.291	0.024	0.705	0.705	0.799	0.799	0.799	0.799	0.658
	3/225	4.01	11.57	0.705	0.390	0.038	0.705	0.705	0.705	0.846	0.799	0.799	0.846	0.705	0.752	0.658
Gallagher	4/225	4.01	11.57	0.282	0.000	0.517	0.705	0.799	0.752	0.705	0.564	0.705	0.611	0.752	0.658	0.611
	5/225	4.01	11.57	0.799	0.752	0.799	0.752	0.799	0.705	0.752	0.752	0.752	0.799	0.611	0.799	0.611
Cane Run	6/225	4.01	11.57	0.658	0.611	0.799	0.752	0.799	0.752	0.752	0.517	0.000	0.465	0.752	0.705	0.658
	1/150	3.4	11.68	0.553	0.000	0.000	0.000	0.000	0.008	0.190	0.245	0.233	0.225	0.170	0.201	0.111
Total	2/150	3.4	11.68	0.134	0.343	0.343	0.296	0.237	0.280	0.296	0.201	0.229	0.249	0.217	0.249	0.253
	3/150	3.4	11.68	0.344	0.304	0.276	0.304	0.237	0.000	0.103	0.237	0.237	0.276	0.296	0.276	0.241
	4/150	3.4	11.68	0.276	0.020	0.000	0.000	0.075	0.229	0.276	0.265	0.229	0.190	0.257	0.265	0.174
	3/147	3.5	11.37	0.346	0.350	0.228	0.212	0.260	0.155	0.110	0.265	0.208	0.057	0.134	0.138	0.204
	4/178	3.5	11.37	0.000	0.000	0.000	0.000	0.000	0.092	0.333	0.366	0.080	0.122	0.211	0.166	0.113
	5/183	3.5	11.37	0.178	0.144	0.166	0.101	0.072	0.166	0.144	0.166	0.122	0.166	0.255	0.144	0.139
Total				6.596	5.393	5.649	6.388	6.223	5.303	6.128	6.423	6.209	6.476	5.244	6.716	6.210

¹ Average yearly sulfur content of coal reported by plants to the Department of Energy.
² Average yearly higher heating value of coal reported by plants to the Department of Energy.

TABLE 5-12. GROUP III - MONTHLY SULFATE MASS EMISSION RATE

EMISSION CONSTANT = 0.0671 mg/MJ
 = 0.6112 mg/MJ
 %S = 1.031
 HHV = 12.261
 = 11.162

Plant	Unit/ size, MW	% S ³	HHV, ⁴ MJ/lb	Monthly sulfate emission rate, kg/h												Average sulfate yearly emis- sion rate, kg/h
				January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	2.49	11.34	0.392	0.000	0.000	0.000	0.078	0.261	0.496	0.522	0.209	0.574	0.574	0.365	0.287
Stuart	1/610	1.2	11.79	0.375	0.302	0.339	0.278	0.048	0.339	0.339	0.375	0.145	0.424	0.266	0.387	0.302
	2/610	1.2	11.79	0.302	0.242	0.278	0.375	0.230	0.351	0.363	0.327	0.194	0.375	0.363	0.290	0.302
	3/610	1.2	11.79	0.302	0.278	0.290	0.133	0.363	0.278	0.351	0.327	0.278	0.302	0.218	0.351	0.290
	4/610	1.2	11.79	0.375	0.290	0.315	0.121	0.387	0.278	0.375	0.363	0.363	0.109	0.363	0.375	0.315
Miami Fort	7/500	2.08	11.99	0.453	0.227	0.515	0.474	0.350	0.371	0.515	0.412	0.433	0.227	0.556	0.577	0.433
	8/500	2.08	11.99	0.515	0.412	0.062	0.433	0.433	0.391	0.371	0.391	0.433	0.433	0.062	0.000	0.330
Tanners Creek	4/500	3.7	11.24	0.823	0.510	0.549	0.588	0.196	0.627	0.941	0.784	0.627	0.274	1.020	0.941	0.666
	1/511	2.1	12.28	0.530	0.510	0.449	0.347	0.469	0.571	0.530	0.571	0.122	0.367	0.571	0.571	0.469
Ghent	2/511	2.1	12.28	0.714	0.530	0.326	0.347	0.224	0.082	0.265	0.245	0.428	0.102	0.082	0.306	0.306
	6/277	3.5	11.37	1.130	0.748	0.863	0.774	0.961	0.934	0.846	1.010	0.774	0.347	0.774	1.100	0.854
M111 Creek	1/335	3.7	11.47	1.34	0.404	0.000	0.470	1.340	1.410	0.122	1.180	1.100	0.827	1.450	1.380	0.996
	2/326	3.7	11.47	1.58	1.354	1.335	1.260	0.705	1.190	1.310	0.884	1.300	1.240	1.470	1.220	1.230
	3/425	3.7	11.47	0.686	1.824	2.190	1.600	1.370	1.980	2.050	1.610	1.930	1.810	0.122	0.000	1.430
Spurlock	1/300	.123	11.97	0.171	0.171	0.159	0.122	0.085	0.122	0.159	0.134	0.122	0.000	0.122	0.134	0.122
Total				9.688	7.800	7.670	7.322	7.240	9.180	9.030	9.140	8.460	7.410	8.010	8.000	8.330

¹ This value used for power plants using an ESP as their only emission control device.

² This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

³ Average yearly sulfur content of coal reported by plants to the Department of Energy.

⁴ Average yearly higher heating value of coal reported by plants to the Department of Energy.

GASEOUS NO_2 AND NO_x EMISSIONS

The total yearly average gaseous NO_2 mass emission rate for all of the power plants operating in the study region is 696 kg/h. The mass emission rate for NO_2 is calculated assuming that everything measured as NO_x is either NO or NO_2 . The method of subtraction was used between the NO and NO_x readings to determine the NO_2 concentration of the flue gas. The gaseous NO_x total mass emission rate is 25,481 kg/h. Figures 5-17 and 5-18 present the total monthly gaseous NO_2 and NO_x mass emission rate. The yearly average gaseous NO_2 mass emission rate for plants in Groups I, II, and III are 69, 188, and 439 kg/h, respectively. The yearly average gaseous NO_x mass emission rate for power plants in Groups I, II, and III are 2,111, 4,459, and 18,911 kg/h, respectively. Tables 5-13 through 5-18 present the yearly average gaseous NO_2 and NO_x mass emission rates on a group basis for each plant operating in the study region. The average monthly gaseous NO_2 and NO_x mass emission rates for Groups I, II, and III are presented in Figures 5-19 through 5-24.

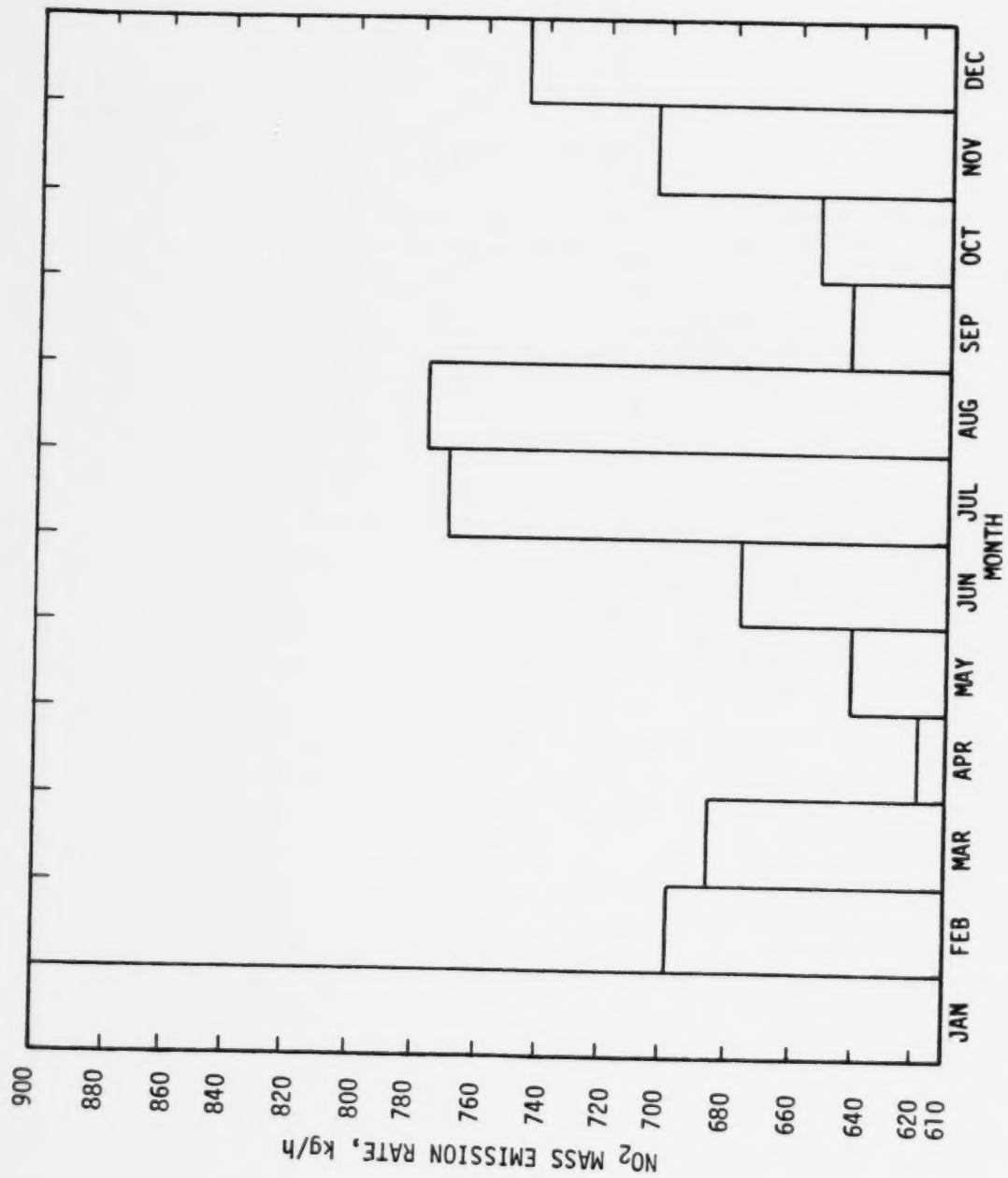


Figure 5-17. Total monthly NO₂ mass emissions.

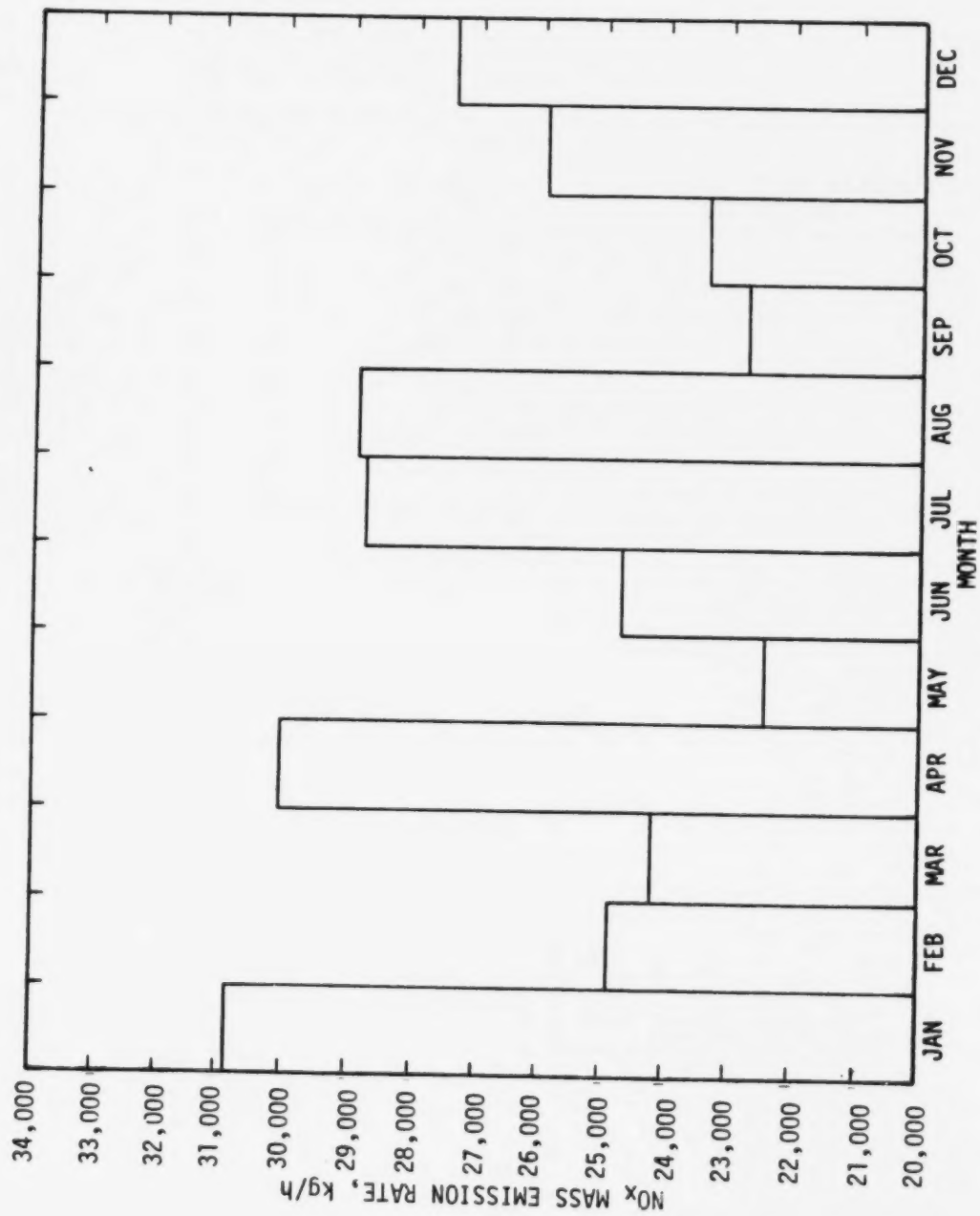


Figure 5-18. Total monthly NO_x mass emissions.

TABLE 5-13. GROUP I - NITROGEN DIOXIDE (NO₂) MASS EMISSION RATE
EMISSION RATE = 9.16 mg/MJ

Plant	Unit/ size, MW	Monthly nitrogen oxide emission rates, kg/h												Average nitrogen oxide yearly emission rate, kg/h
		January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	2.28	1.78	1.54	2.66	1.05	0.33	0.00	0.31	0.00	0.04	0.43	1.29	0.97
	4/69	1.50	1.29	1.76	0.28	0.38	0.15	0.00	1.01	0.19	0.00	0.95	1.08	0.71
	5/71	1.81	0.00	0.49	0.08	0.00	0.00	0.26	1.74	0.19	0.00	0.17	0.07	0.40
	6/71	1.22	0.00	0.16	0.00	0.69	0.21	0.08	1.54	0.28	0.00	0.00	0.07	0.35
Beckford	1/115	10.24	9.82	10.20	8.67	9.75	8.74	7.66	8.04	8.60	8.60	8.32	7.73	8.86
	2/112.5	8.34	8.48	8.89	8.14	7.70	7.77	6.81	6.92	7.33	7.56	4.84	3.92	7.22
	3/125	7.24	11.13	12.15	10.11	9.20	10.86	7.31	10.52	7.41	0.87	4.60	9.91	8.44
Miami Fort Tanners Creek	5/100	0.20	4.24	5.30	2.41	6.74	5.29	1.55	0.00	0.00	3.26	4.44	3.67	3.09
	1/150	8.18	9.07	9.90	10.10	7.63	0.00	7.46	7.35	6.32	10.83	3.32	9.69	7.90
	2/150	10.00	11.54	10.23	7.96	3.97	12.18	4.76	3.47	6.70	16.84	8.37	8.74	8.73
Cane Run	3/215	19.46	17.10	12.56	12.53	19.07	14.71	12.21	10.63	11.53	12.95	10.70	12.32	13.82
	1/112.5	12.19	10.57	6.42	6.98	6.02	1.72	0.00	6.12	1.97	0.00	0.81	0.35	4.43
Total	2/112.5	8.81	8.62	2.21	4.57	5.42	3.58	3.97	3.97	1.93	3.44	0.00	0.00	3.88
		91.47	93.64	81.82	74.49	77.62	65.54	52.07	61.62	52.50	64.39	51.95	58.84	68.80

TABLE 5-14. GROUP II - NITROGEN DIOXIDE (NO₂) MASS EMISSION RATE
EMISSION RATE = 9.95 mg/MJl
= 5.41 mg/MJl

Plant	Unit/ size, MW	Monthly nitrogen oxide emission rates, kg/h												Average nitrogen oxide yearly emission rate, kg/h
		January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	15.92	17.01	17.31	15.82	12.64	7.06	12.34	18.31	16.12	14.63	13.23	12.94	14.44
	5/244	16.52	19.00	24.78	22.89	26.27	17.21	16.22	17.71	18.01	21.59	16.12	20.00	19.69
Miami Fort Clifty Creek	6/168	15.62	14.63	15.62	14.23	15.62	10.35	14.03	16.12	14.23	9.25	0.00	0.60	11.69
	1/225	16.02	17.61	16.02	17.91	19.50	18.51	0.00	5.37	19.51	17.91	20.10	21.39	15.82
	2/225	17.91	18.21	16.32	19.50	7.66	0.60	19.20	19.20	20.80	21.69	20.50	21.39	16.92
	3/225	18.81	21.59	10.25	1.00	18.11	18.11	22.59	20.90	21.19	21.89	18.11	19.80	17.70
	4/225	7.46	0.00	14.33	18.01	21.79	20.20	19.00	15.52	18.71	16.22	20.20	17.11	15.71
	5/225	20.99	20.00	21.29	20.00	21.29	19.00	20.30	19.70	19.40	20.99	16.22	20.99	20.01
Gallagher	6/225	17.91	16.02	21.09	20.40	21.39	19.80	19.80	13.53	0.00	12.24	20.40	18.51	16.76
	1/150	1.79	0.00	0.00	0.00	0.00	0.30	5.97	7.66	7.36	7.06	5.37	6.27	3.48
	2/150	4.18	10.15	10.15	9.35	7.46	8.76	9.35	6.27	7.16	7.76	6.86	7.76	7.93
	3/150	10.75	9.55	8.66	9.55	7.46	0.00	3.28	7.46	7.46	8.66	9.25	8.66	7.56
Cane Run	4/150	8.66	0.60	0.00	0.00	2.39	7.16	8.66	8.36	7.16	5.97	8.06	8.36	5.45
	3/147	10.55	10.64	6.96	6.47	7.96	4.78	3.38	8.06	6.37	1.79	4.08	4.18	6.27
	4/178	0.00	0.00	0.00	0.00	0.00	3.15	12.01	13.20	2.92	4.54	7.68	6.28	3.41
Total	5/183	6.33	5.25	6.11	3.68	2.65	6.11	5.41	6.22	4.60	5.95	9.31	5.30	5.58
		189.42	180.26	188.89	178.82	192.19	161.30	191.54	203.59	191.00	198.14	195.49	199.54	188.42

¹ This value used for power plants using an ESP as their only emission control device.
² This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

TABLE 5-15. GROUP III - NITROGEN DIOXIDE (NO₂) MASS EMISSION RATE
EMISSION RATE = 11.81 mg/MJ¹
= 5.25 mg/MJ²

Plant	Unit/ size, MW	Monthly nitrogen oxide emission rates, kg/h												Average nitrogen oxide yearly emission rate, kg/h
		January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	29.41	0.00	0.00	0.00	6.50	19.01	36.61	37.67	14.76	42.28	41.93	26.93	10.77
Stuart	1/610	60.58	47.48	53.38	43.58	7.32	53.26	53.97	59.05	22.08	66.14	42.52	61.77	47.59
	2/610	47.12	37.91	44.64	43.58	35.78	55.03	58.22	52.08	29.88	59.64	57.51	46.53	47.33
	3/610	47.12	43.70	46.65	21.26	57.75	44.64	54.68	52.44	44.52	48.07	34.37	55.93	45.93
	4/610	60.23	46.41	50.55	19.49	61.88	44.17	59.17	59.22	57.16	16.77	57.16	59.88	49.26
Miami Fort	7/500	42.04	21.38	48.30	44.64	33.19	35.19	47.12	38.85	40.98	21.38	51.61	54.21	42.84
	8/500	47.00	38.85	6.14	40.63	39.56	36.37	33.54	35.90	40.27	39.44	5.20	0.00	30.24
Tanners Creek	4/500	39.33	25.63	26.45	28.93	9.45	30.94	46.77	38.38	31.06	13.46	49.01	46.18	32.13
	1/511	48.89	47.48	42.99	32.83	43.22	52.79	50.19	53.74	11.46	35.31	54.33	53.97	43.93
Ghent	2/511	66.37	49.48	31.06	32.24	21.14	6.85	25.27	22.32	40.39	9.33	8.50	28.46	28.45
	6/277	10.92	7.19	8.30	7.46	9.24	8.98	8.14	9.77	7.51	3.31	7.51	10.66	8.25
Cane Run	1/355	12.28	3.68	0.00	4.25	12.28	12.92	1.16	10.71	16.13	7.56	13.23	12.65	8.40
	2/326	14.44	12.34	12.18	11.50	6.46	10.87	11.92	8.03	11.81	11.34	13.44	11.13	11.29
	3/425	6.30	16.70	20.00	14.60	12.55	18.11	18.69	14.70	17.59	16.59	1.10	0.00	13.08
Spurlock	1/300	27.28	25.86	25.51	20.09	13.70	19.60	21.61	21.02	18.54	0.00	19.37	21.14	19.48
Total		559.31	424.09	416.15	365.07	370.02	449.73	527.06	512.88	398.14	390.62	456.79	489.49	438.97

¹This value used for power plants using an ESP as their only emission control device.

²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

TABLE 5-16. GROUP I - NITROGEN OXIDE (NO_x) MASS EMISSION RATE
EMISSION FACTOR = 278.33 mg/MJ

Plant	Unit/ size, MW	Monthly nitrogen oxide emission rates, kg/h												Average nitrogen oxide yearly emission rate, kg/h
		January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	69.36	53.95	46.74	80.89	31.86	37.78	0.00	9.42	0.00	1.23	13.11	39.26	31.97
	4/69	45.68	39.08	53.34	8.62	11.62	4.58	0.00	30.54	5.81	0.00	28.78	32.83	21.74
	5/71	55.02	0.00	14.84	2.56	0.00	0.00	78.60	52.73	5.92	0.00	5.21	2.12	18.08
Beckjord	6/71	37.03	0.00	4.93	0.00	21.11	6.51	2.46	46.80	8.53	0.00	0.00	2.11	10.79
	1/115	311.11	298.41	310.05	263.49	296.29	265.61	232.80	244.44	261.37	261.37	252.91	234.92	269.40
	2/112.5	253.64	257.78	270.21	247.43	233.97	236.04	207.06	210.16	222.59	229.83	147.01	119.06	219.56
Miami Fort	3/125	220.01	338.23	369.07	307.39	279.64	330.01	222.06	319.73	225.15	26.43	139.82	301.22	256.56
	5/100	6.10	128.89	161.11	73.15	204.65	159.37	47.03	0.00	0.00	97.54	134.98	111.47	93.69
	1/150	248.54	275.70	300.76	307.02	231.83	0.00	87.45	223.48	192.15	328.96	252.72	294.50	228.59
Tanners Creek	2/150	303.98	350.50	311.21	241.94	399.10	370.15	144.75	105.46	203.68	511.80	254.35	265.72	288.55
	3/215	591.35	519.70	381.76	380.69	579.59	446.99	371.06	322.93	351.81	393.52	325.09	374.27	419.90
	1/112.5	370.34	321.11	195.13	212.03	182.86	52.25	0.00	185.91	59.92	0.00	24.58	10.70	134.57
Cane Run	2/112.5	267.61	261.90	67.26	138.81	164.57	108.76	120.60	120.60	58.68	104.46	0.00	0.00	117.77
	Total	2779.77	2845.25	2486.41	2264.02	2637.09	2018.04	1513.87	1872.21	1595.60	1955.14	1579.45	1788.18	2111.17

TABLE 5-17. GROUP II - NITROGEN OXIDE (NO_x) MASS EMISSION RATE
EMISSION FACTOR = 213.75¹ mg/MJ
= 355.002 mg/MJ

Plant	Unit/ size, MW	Monthly nitrogen oxide emission rates, kg/h												Average nitrogen oxide yearly emission rate, kg/h
		January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	342.00	365.51	371.92	339.86	271.46	151.76	265.05	393.30	346.28	314.21	284.29	277.88	310.29
	5/244	354.82	409.26	532.24	491.62	564.30	369.79	343.41	380.49	386.89	463.84	346.28	429.64	423.05
Miami Fort	6/168	335.59	314.21	322.76	305.66	335.59	222.30	301.39	346.28	305.66	198.79	0.00	12.82	250.09
	1/225	344.14	378.34	344.14	334.75	418.95	397.58	0.00	115.42	418.95	384.75	431.78	459.56	339.86
Clifty Creek	2/225	384.75	391.16	350.55	418.95	164.59	12.82	412.54	412.54	446.74	465.98	440.32	459.56	363.38
	3/225	403.99	461.84	220.16	21.38	399.02	389.02	435.21	449.09	455.29	470.25	389.02	425.36	347.70
Gallagher	4/225	160.31	0.00	307.80	363.89	469.11	433.91	400.26	333.45	401.85	348.41	433.91	367.65	336.04
	5/225	451.01	429.64	457.64	429.64	457.42	408.26	436.05	423.22	416.81	451.01	348.41	451.01	429.99
Cane Run	6/225	384.75	344.14	453.15	438.19	459.56	425.36	425.36	290.70	0.00	262.91	438.91	397.58	359.99
	1/150	38.48	0.00	0.00	0.00	0.00	6.41	128.25	164.59	158.18	151.76	115.42	134.66	74.81
Total	2/150	89.78	218.02	219.02	200.92	160.31	183.10	200.92	134.66	153.90	166.72	147.49	166.72	170.46
	3/150	230.85	205.20	185.96	205.20	160.31	0.00	70.54	160.54	160.31	135.96	198.79	185.96	162.45
Total	4/150	185.96	12.82	0.00	0.00	51.30	153.90	185.96	179.55	153.90	128.25	173.14	179.55	117.03
	3/147	226.59	228.71	149.62	138.94	171.00	102.60	72.68	173.14	136.80	38.48	87.64	89.78	134.66
Total	4/178	0.00	0.00	0.00	0.00	0.00	220.10	788.10	866.20	191.70	298.20	504.10	411.80	273.35
	5/183	415.35	344.35	401.15	241.40	173.95	401.15	355.00	403.25	301.75	390.50	610.60	347.90	365.94
Total		4343.36	4104.20	4096.87	3915.40	4245.96	3993.06	4093.72	5230.97	5535.01	4918.81	4949.38	4797.43	4459.09

¹This value used for power plants using an ESP as their only emission control device.
²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

TABLE 5-18. GROUP III - NITROGEN OXIDE (NO_x) MASS EMISSION RATE
EMISSION FACTOR = 507.781 mg/MJ
= 802.002 mg/MJ

Plant	Unit/ size, MW	Monthly nitrogen oxide emission rates, kg/h												Average nitrogen oxide yearly emission rate, kg/h
		January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	1,264	0	0	0	279	818	1,574	1,620	635	1,818	1,803	1,158	914
Stuart	1/610	2,605	2,041	2,295	1,974	315	2,200	2,321	2,539	950	2,844	1,828	2,656	2,046
	2/610	2,026	1,630	1,919	2,549	1,539	2,306	2,503	2,239	1,285	2,564	2,473	2,001	2,091
	3/610	2,206	1,879	2,006	2,914	2,483	1,919	2,351	2,255	1,914	2,067	1,478	2,407	1,975
	4/610	2,590	1,906	2,173	838	2,261	1,999	2,544	2,503	2,458	721	2,458	2,574	2,118
Miami Fort	7/500	1,808	919	2,077	1,919	1,427	1,513	2,206	1,671	1,762	919	2,219	2,331	1,716
	8/500	2,021	1,671	264	1,747	1,701	1,564	1,442	1,544	1,732	1,696	223	0	1,300
Tanners Creek	4/500	1,691	1,102	1,137	1,244	406	1,330	2,011	1,650	1,335	579	2,107	1,985	1,381
Ghent	1/511	2,102	2,041	1,849	1,412	1,858	2,270	2,158	2,310	493	1,518	2,336	2,321	1,889
	2/511	2,854	2,123	1,335	1,386	909	295	1,087	960	1,737	401	366	1,224	1,223
Cane Run	6/277	379	249	288	258	320	311	292	339	260	115	260	369	286
Mill Creek	1/335	426	127	0	147	426	440	40	371	351	262	459	439	291
	2/326	501	428	422	309	224	377	413	278	410	393	466	386	391
	3/425	218	579	691	506	435	628	648	510	610	575	38	0	453
Spurlock	1/300	1,173	1,112	1,097	863	589	843	929	904	797	0	833	909	837
Total		23,683	17,901	17,556	23,726	15,572	19,871	22,329	21,692	16,727	16,472	19,346	20,759	18,911

¹This value used for power plants using an ESP as their only emission control device.

²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

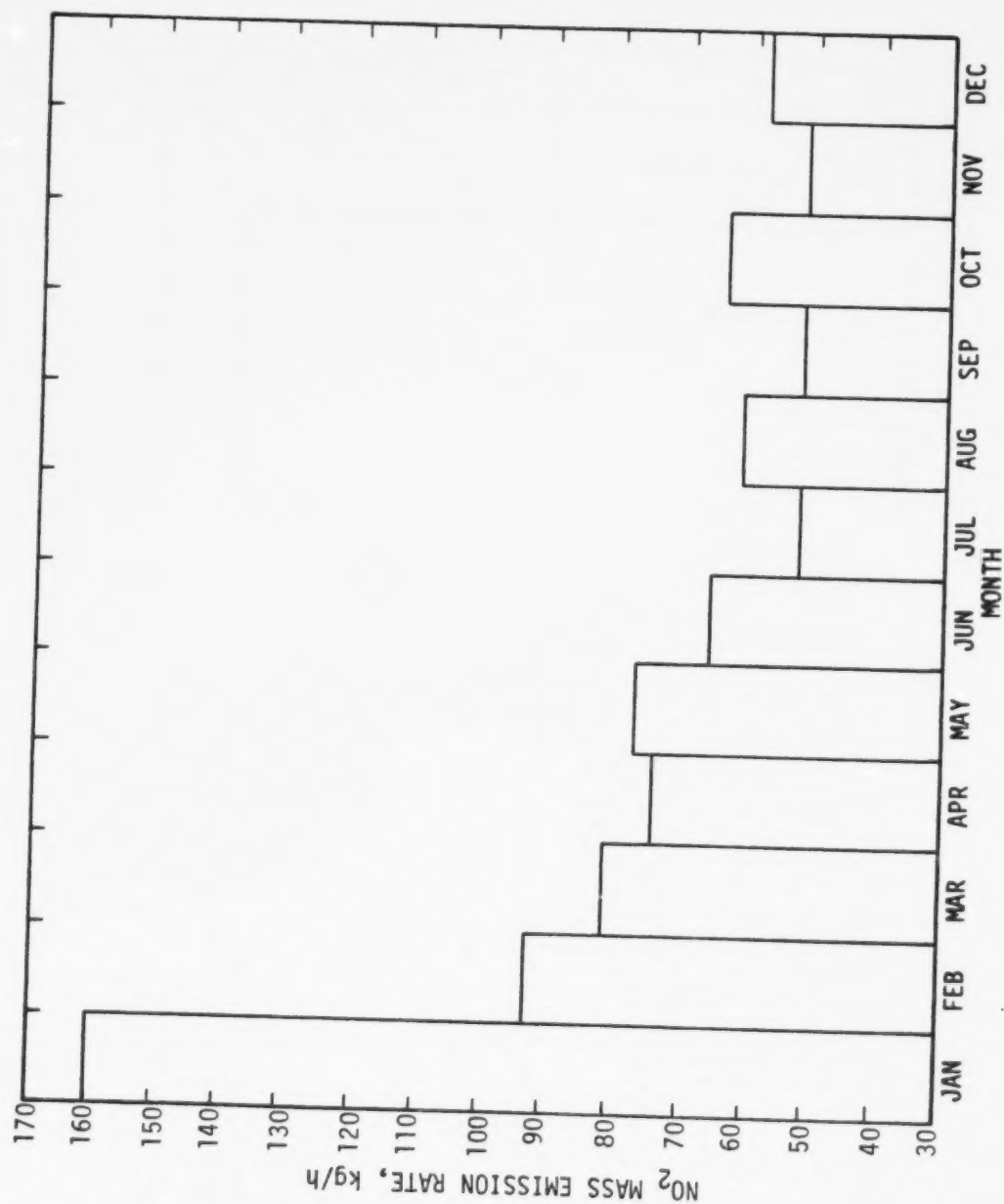


Figure 5-19. Group I monthly NO₂ mass emissions.

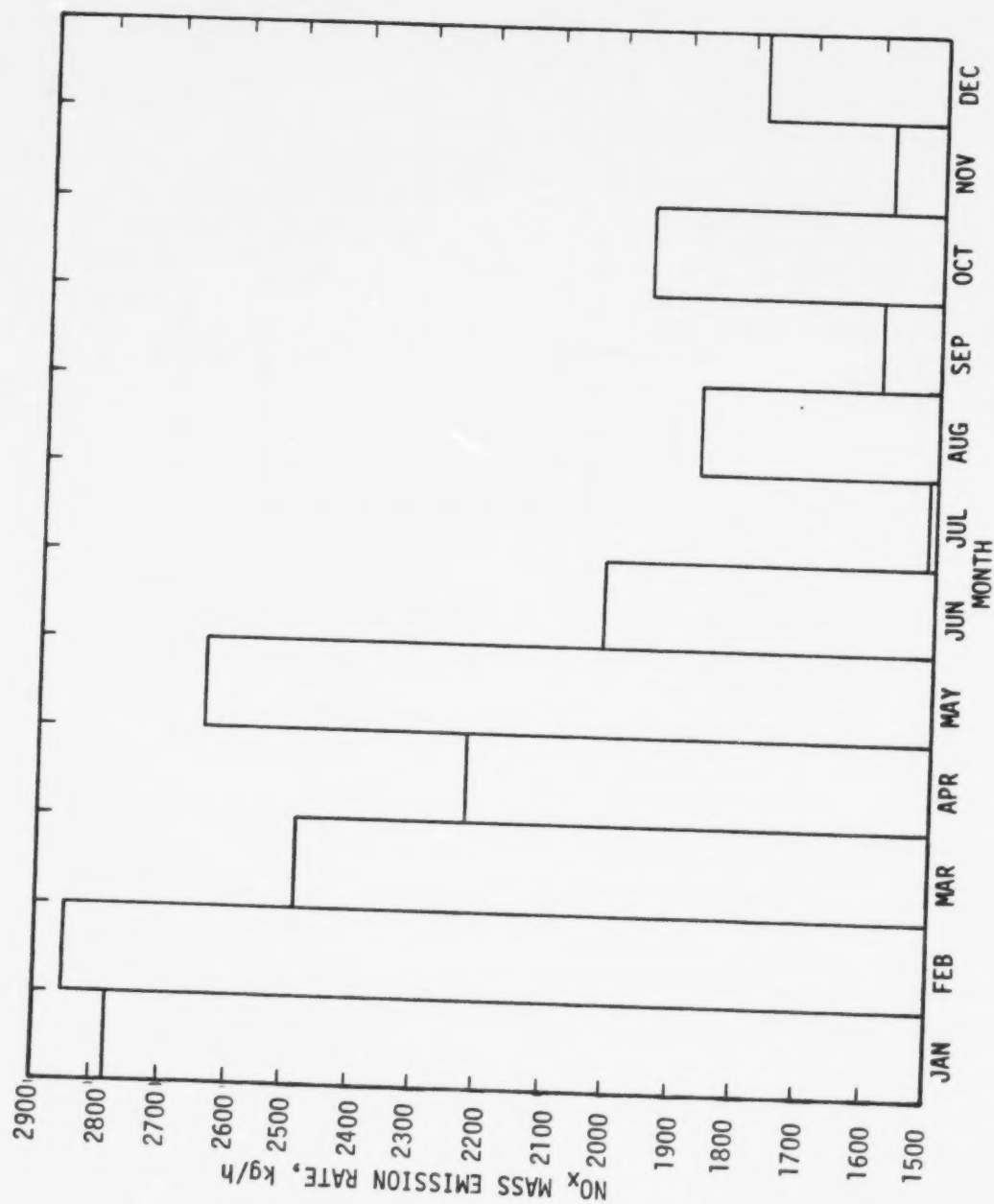


Figure 5-20. Group I monthly NO_x mass emissions.

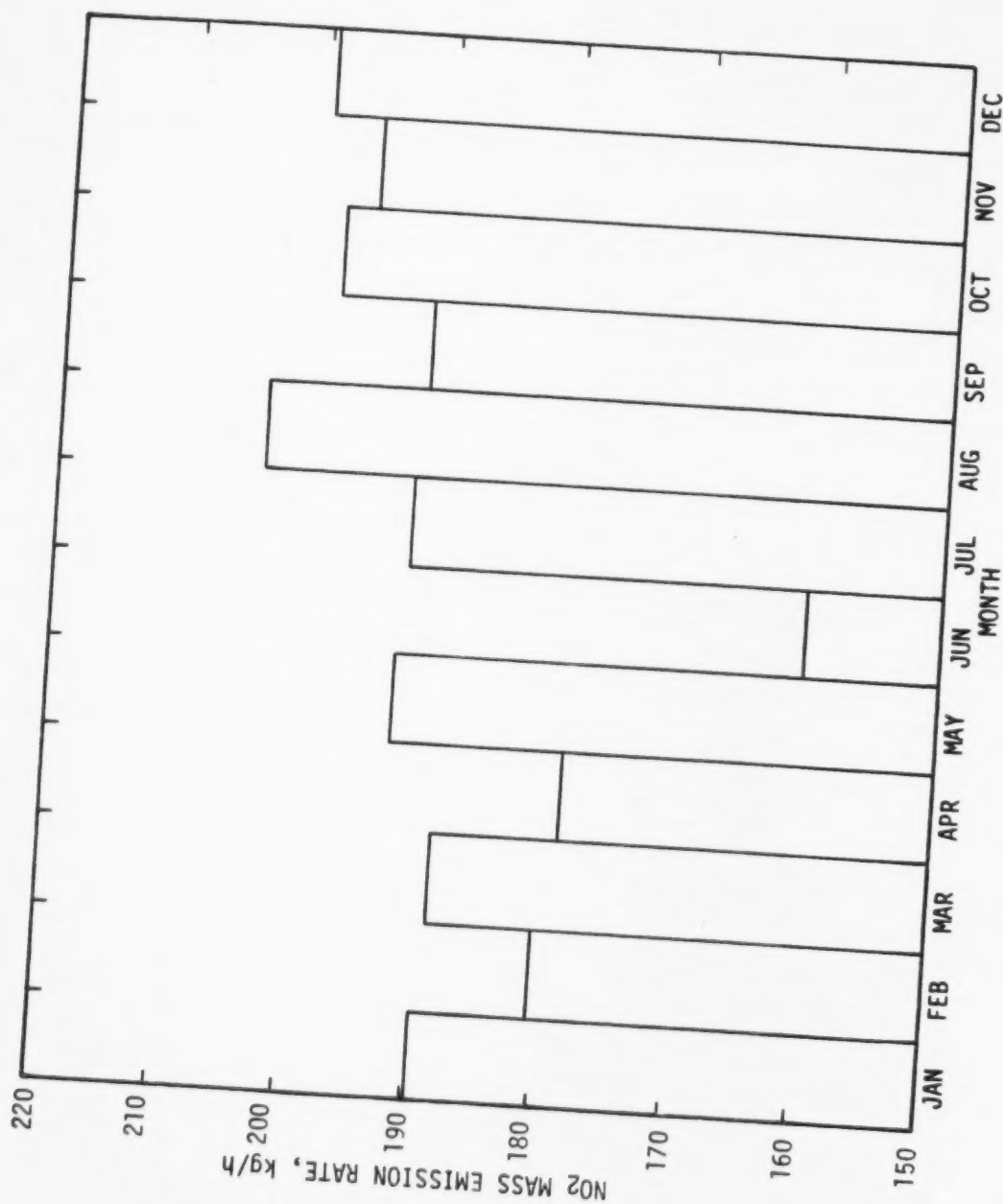


Figure 5-21. Group II monthly NO₂ mass emissions.

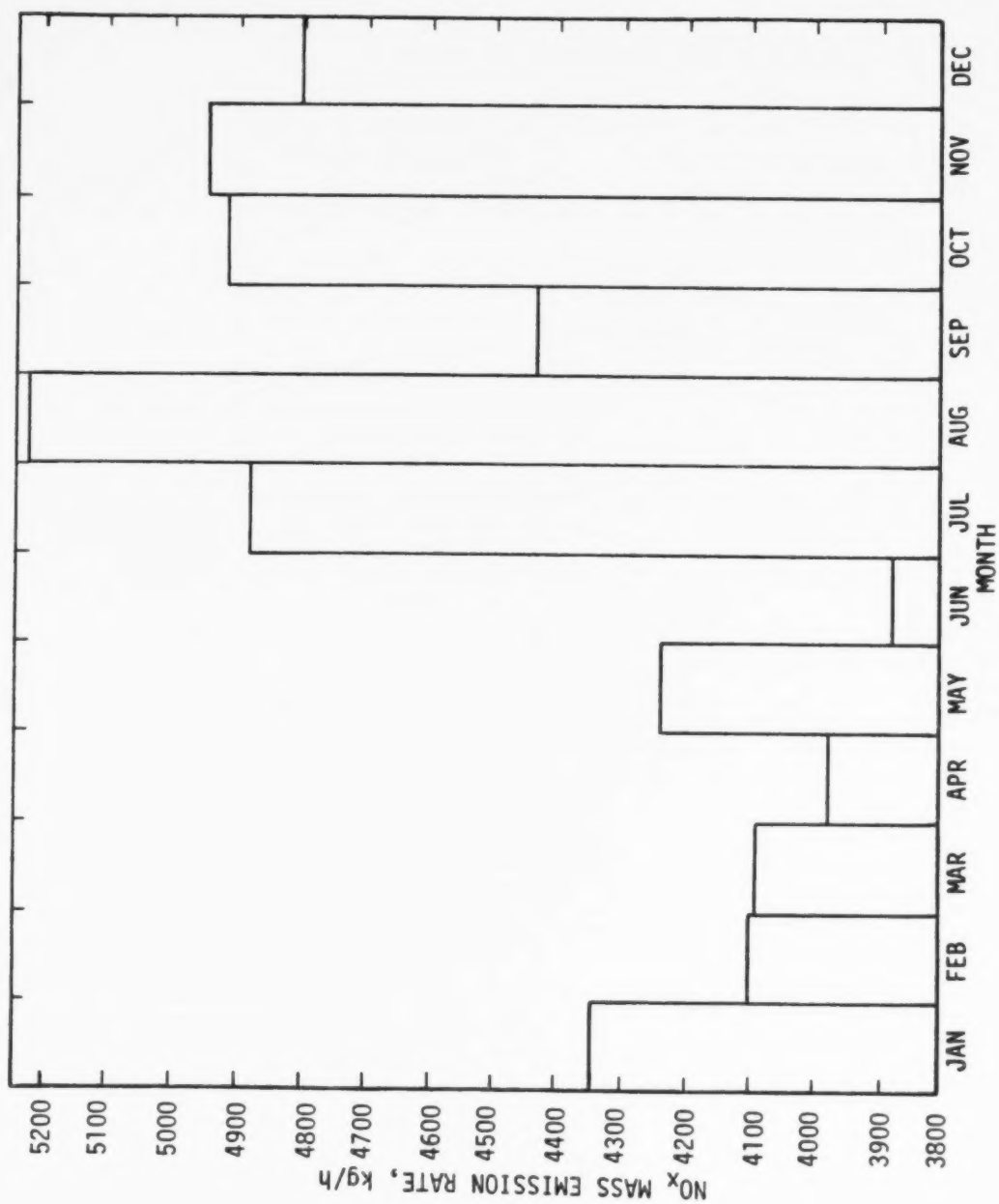


Figure 5-22. Group II monthly NO_x mass emissions.

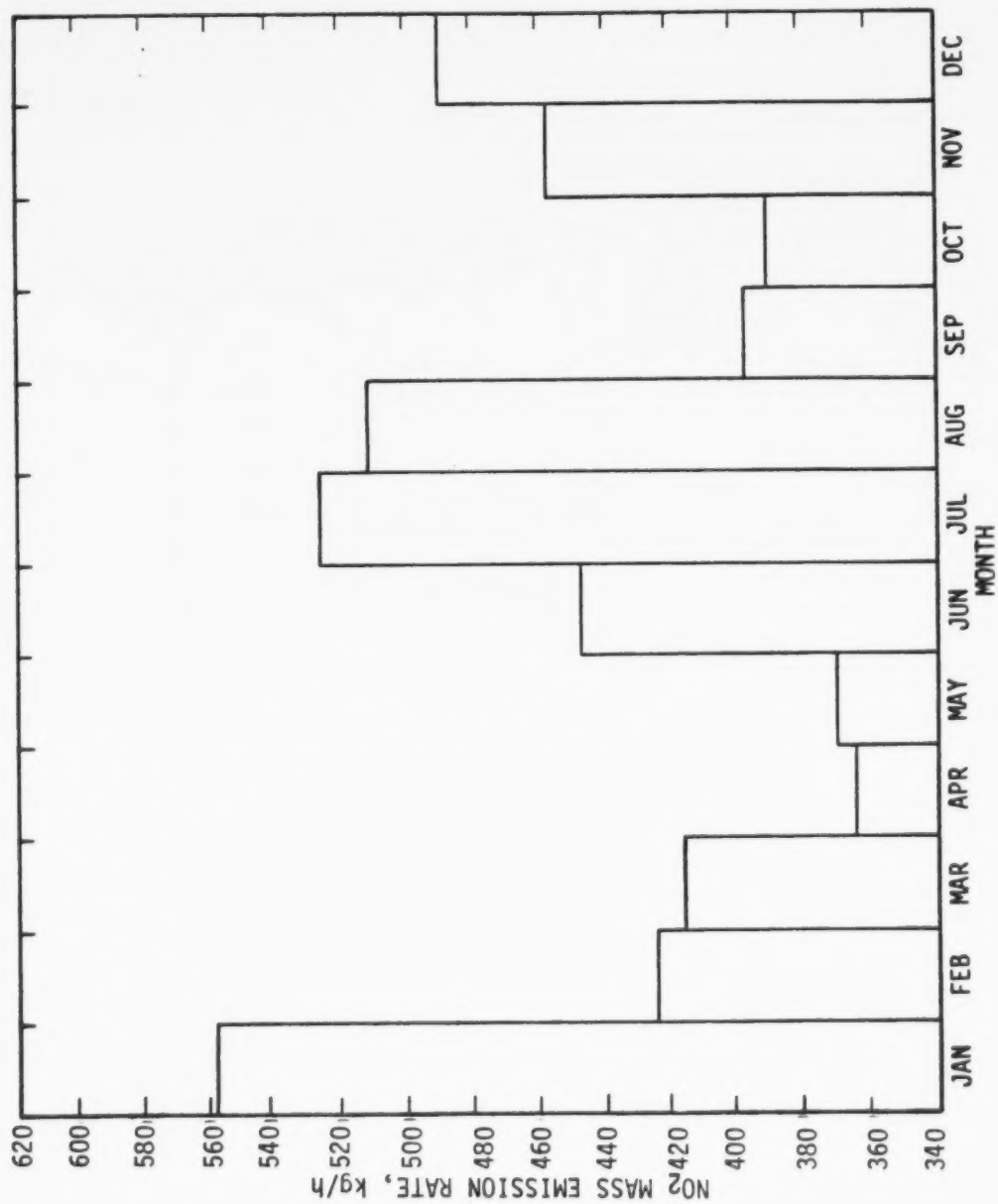


Figure 5-23. Group III monthly NO₂ mass emissions.

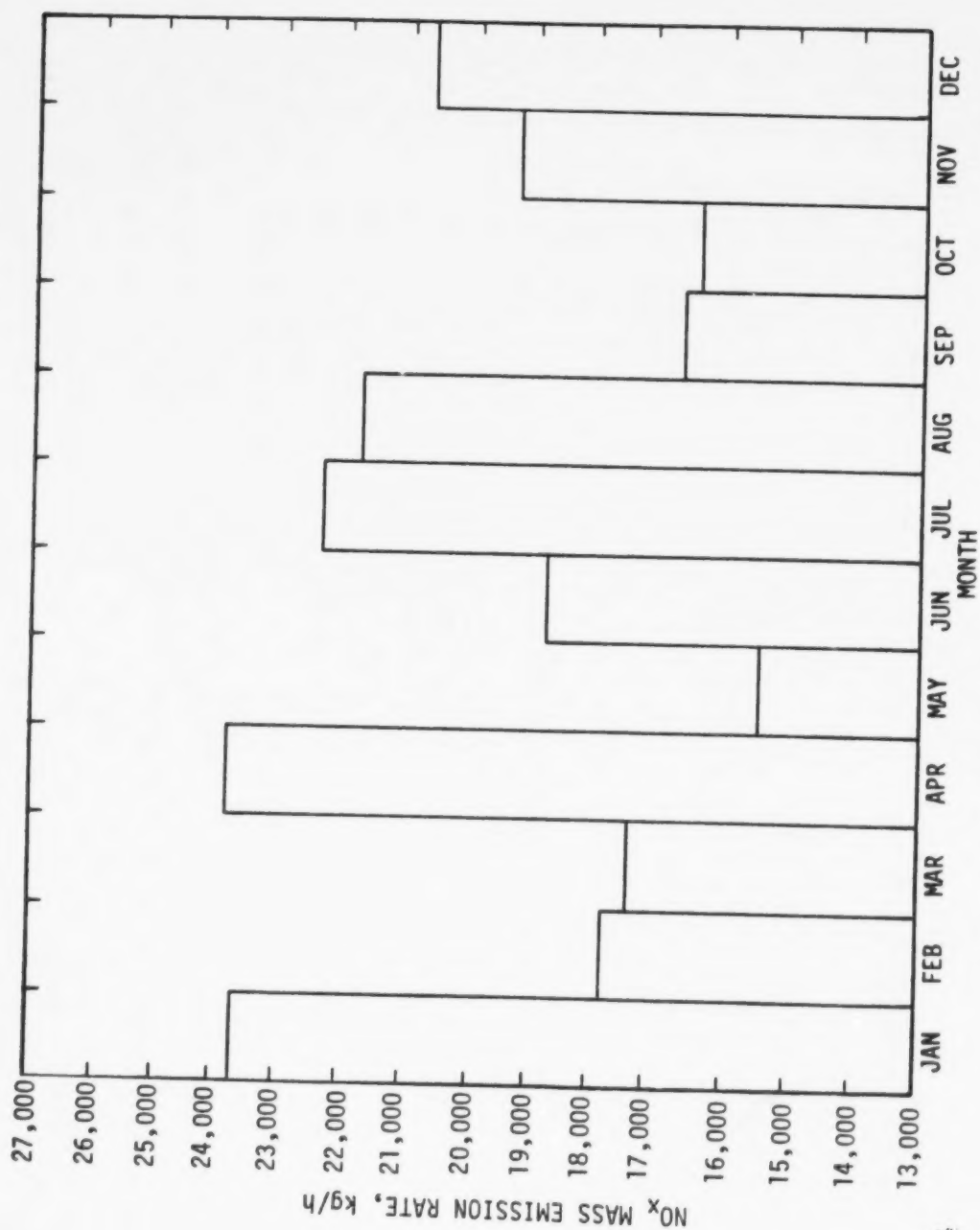


Figure 5-24. Group III monthly NO_x mass emissions.

PARTICULATE AND GASEOUS CHLORIDE EMISSION RATES

For determining particulate chloride emission rates for power plants in Group II, the emission factor used was the value calculated for Plant E. The emission factor calculated for Plant C was not used due to improper operations of the unit resulting in heavy particulate loading. For determining particulate chloride emission rates for power plants in Group III, an average of Plant A and E emission factors was used since both values compared very closely.

The total yearly average particulate chloride mass emission rate for all of the plants operating in the study region is 2.6 kg/h. The gaseous HCl total mass emission rate is 2501 kg/h. Figures 5-25 and 5-26 present the total monthly particulate chloride and gaseous HCl mass emission rates. The yearly average particulate chloride mass emission rates for plants in Groups I, II, and III are 0.32, 0.77, and 1.5 kg/h, respectively. The yearly average gaseous HCl mass emission rate for plants in the Groups I, II, and III categories are 245, 745, and 1511 kg/h, respectively. Tables 5-19 through 5-24 present the yearly average particulate chloride and gaseous HCl mass emission rates on a group basis for each plant operating in the study region.

The average monthly particulate chloride and gaseous HCl mass emission rates for Groups I, II, and III are presented in Figures 5-27 through 5-32.

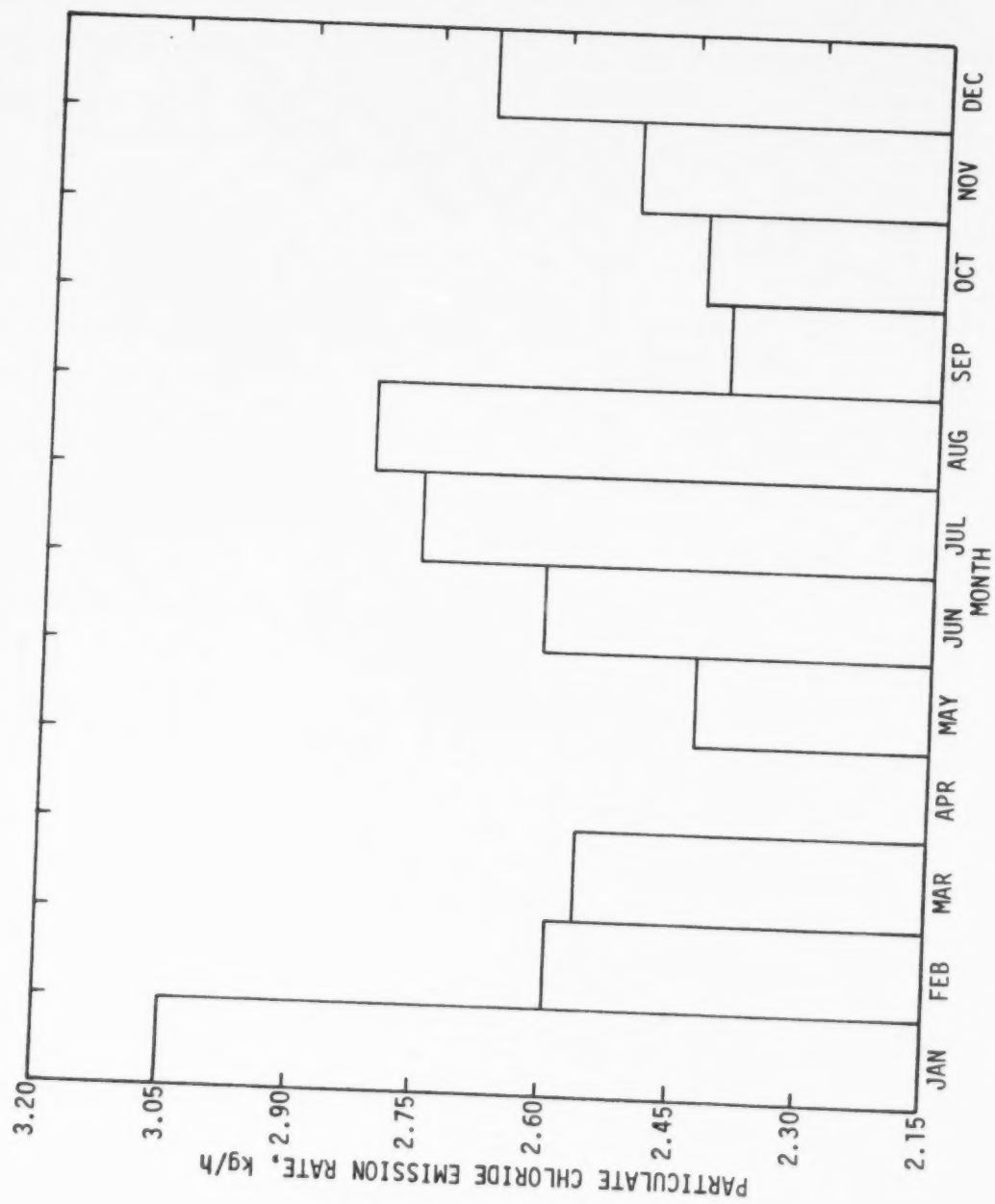


Figure 5-25. Total monthly particulate chloride mass emissions.

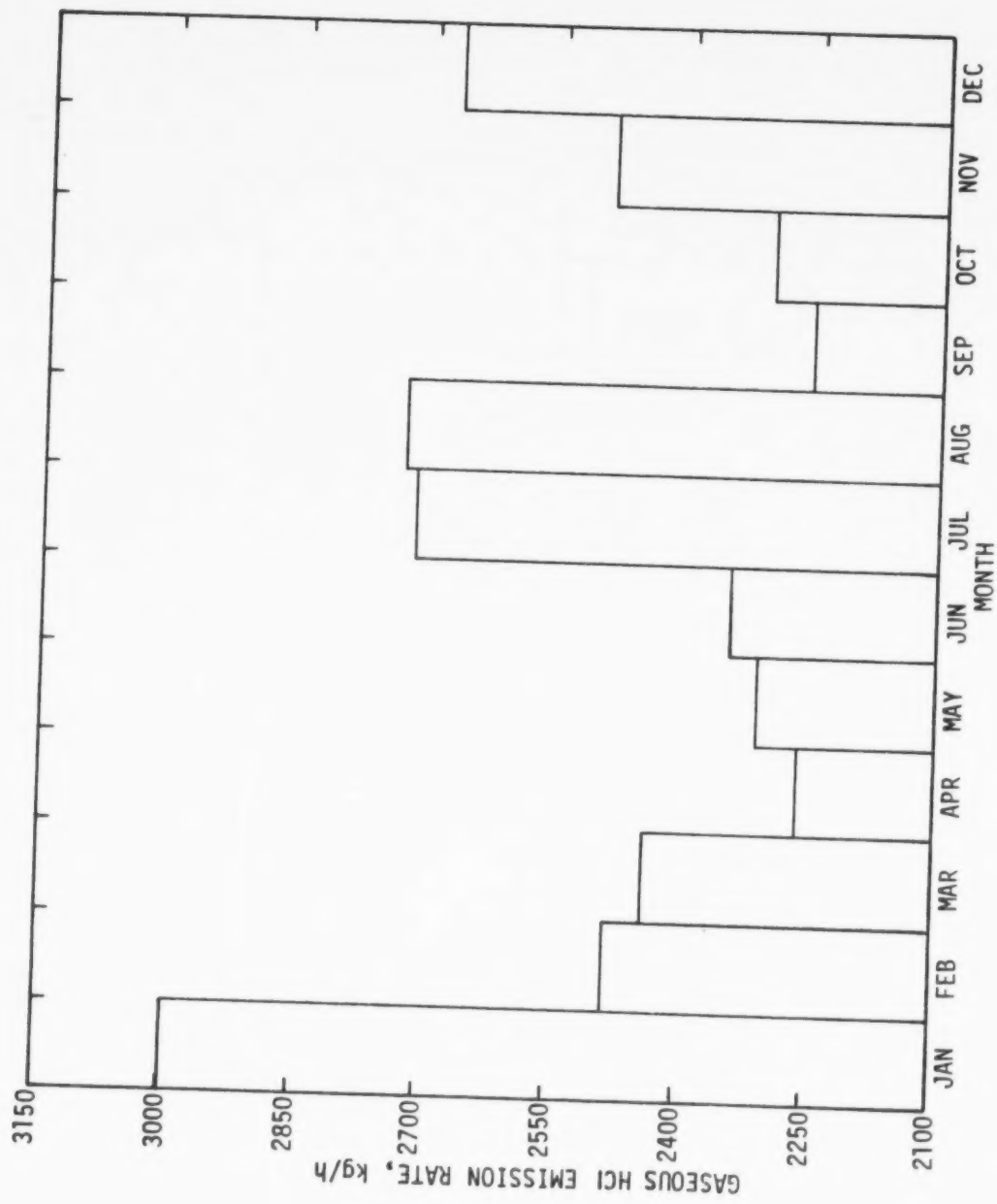


Figure 5-26. Total monthly gaseous HCL mass emissions.

TABLE 5-19. GROUP I - MONTHLY PARTICULATE CHLORIDE MASS EMISSION RATE
EMISSION FACTOR = 0.042 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly particulate chloride emissions, kg/h												Average particulate chloride yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	12.35	0.011	0.008	0.007	0.012	0.005	0.001	0.000	0.001	0.000	0.0	0.002	0.006	0.005
	4/69	13.31	0.007	0.006	0.008	0.001	0.002	0.001	0.000	0.005	0.001	0.0	0.004	0.005	0.003
	5/71	12.85	0.008	0.000	0.002	0.000	0.000	0.000	0.001	0.008	0.001	0.0	0.001	0.000	0.002
Beckjord	6/71	13.00	0.006	0.000	0.001	0.000	0.003	0.001	0.000	0.007	0.001	0.0	0.000	0.000	0.002
	1/115	11.28	0.047	0.045	0.047	0.040	0.045	0.040	0.035	0.037	0.039	0.039	0.038	0.035	0.041
	2/112.5	11.31	0.038	0.039	0.041	0.037	0.035	0.036	0.031	0.034	0.034	0.035	0.022	0.018	0.033
Miami Fort	3/125	11.27	0.033	0.051	0.056	0.046	0.042	0.050	0.034	0.048	0.034	0.021	0.021	0.045	0.040
	5/100	10.72	0.001	0.019	0.024	0.011	0.031	0.024	0.007	0.000	0.0	0.015	0.020	0.017	0.014
	1/150	10.80	0.038	0.042	0.045	0.046	0.035	0.000	0.034	0.034	0.029	0.050	0.033	0.044	0.036
Tanners Creek	2/150	10.82	0.046	0.053	0.047	0.037	0.060	0.056	0.022	0.016	0.031	0.046	0.033	0.040	0.041
	3/215	10.64	0.089	0.078	0.058	0.057	0.097	0.067	0.056	0.049	0.053	0.059	0.049	0.056	0.063
	1/112.5	11.71	0.056	0.048	0.029	0.032	0.028	0.008	0.000	0.028	0.009	0.000	0.004	0.002	0.020
Cane Run	2/112.5	11.28	0.040	0.039	0.010	0.021	0.025	0.025	0.016	0.020	0.009	0.016	0.000	0.000	0.018
			0.42	0.428	0.375	0.340	0.343	0.309	0.236	0.247	0.241	0.281	0.237	0.268	0.317
Total															

TABLE 5-20. GROUP II - MONTHLY PARTICULATE CHLORIDE MASS EMISSION RATE
EMISSION FACTOR = 0.04 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly particulate chloride emissions, kg/h												Average particulate chloride yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	12.54	0.07	0.07	0.07	0.07	0.05	0.03	0.05	0.08	0.07	0.06	0.05	0.05	0.06
	5/244	10.23	0.07	0.08	0.10	0.09	0.11	0.07	0.07	0.07	0.07	0.09	0.07	0.08	0.08
	6/168	9.63	0.06	0.06	0.06	0.06	0.06	0.04	0.06	0.07	0.06	0.04	0.00	0.00	0.05
Miami Fort Clifty Creek	1/225	10.24	0.07	0.07	0.07	0.07	0.08	0.08	0.00	0.02	0.08	0.07	0.08	0.09	0.06
	2/225	10.14	0.07	0.08	0.07	0.08	0.03	0.00	0.08	0.03	0.09	0.09	0.08	0.09	0.07
	3/225	10.23	0.08	0.09	0.04	0.00	0.07	0.07	0.09	0.09	0.09	0.09	0.07	0.08	0.07
	4/225	10.23	0.03	0.00	0.06	0.07	0.09	0.08	0.08	0.06	0.08	0.07	0.08	0.07	0.07
	5/225	10.19	0.09	0.08	0.09	0.08	0.09	0.03	0.08	0.08	0.08	0.09	0.07	0.06	0.06
	6/225	10.22	0.07	0.07	0.09	0.08	0.09	0.08	0.08	0.06	0.00	0.05	0.08	0.08	0.07
Gallagher	1/150	11.30	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.03	0.02	0.03	0.01
	2/150	10.59	0.02	0.04	0.04	0.04	0.03	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03
	3/150	10.50	0.04	0.04	0.04	0.04	0.03	0.00	0.01	0.03	0.03	0.04	0.04	0.04	0.03
	4/150	11.54	0.04	0.00	0.00	0.00	0.01	0.03	0.04	0.03	0.03	0.02	0.03	0.03	0.02
Cane Run	3/147	11.36	0.04	0.04	0.03	0.02	0.03	0.02	0.01	0.03	0.02	0.01	0.02	0.02	0.02
	4/178	11.12	0.00	0.00	0.00	0.00	0.00	0.02	0.06	0.06	0.01	0.02	0.04	0.03	0.02
	5/183	10.96	0.04	0.04	0.04	0.03	0.02	0.04	0.04	0.04	0.03	0.04	0.02	0.04	0.04
Total			0.80	0.76	0.80	0.73	0.79	0.63	0.31	0.96	0.80	0.84	0.78	0.85	0.77

TABLE 5-21. GROUP III - MONTHLY PARTICULATE CHLORIDE MASS EMISSION RATE
EMISSION FACTOR = 0.035 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly particulate chloride emissions, kg/h												Average particulate chloride yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	11.02	0.09	0.00	0.00	0.00	0.02	0.06	0.11	0.11	0.04	0.13	0.12	0.08	0.06
Stuart	1/610	10.67	0.18	0.14	0.16	0.13	0.02	0.16	0.16	0.17	0.07	0.20	0.13	0.18	0.14
	2/610	10.77	0.14	0.11	0.13	0.18	0.11	0.16	0.17	0.15	0.09	0.19	0.17	0.14	0.14
	3/610	10.07	0.14	0.13	0.14	0.06	0.17	0.13	0.16	0.16	0.13	0.14	0.10	0.17	0.14
	4/610	9.85	0.18	0.14	0.15	0.06	0.18	0.13	0.18	0.17	0.17	0.05	0.17	0.18	0.15
Miami Fort	7/500	10.79	0.12	0.06	0.14	0.13	0.10	0.20	0.14	0.11	0.12	0.06	0.15	0.16	0.12
	8/500	10.43	0.14	0.12	0.02	0.12	0.12	0.11	0.10	0.11	0.12	0.12	0.02	0.00	0.09
Tanners Creek	4/500	10.42	0.12	0.08	0.08	0.09	0.03	0.09	0.14	0.11	0.09	0.04	0.15	0.14	0.10
Ghent	1/511	10.54	0.15	0.14	0.13	0.10	0.13	0.16	0.15	0.16	0.03	0.10	0.16	0.16	0.13
	2/511	10.55	0.20	0.15	0.09	0.10	0.06	0.02	0.07	0.07	0.12	0.03	0.03	0.08	0.08
Cane Run	6/277	10.96	0.07	0.05	0.06	0.05	0.06	0.06	0.06	0.07	0.05	0.02	0.05	0.07	0.06
Mill Creek	1/335	10.51	0.08	0.02	0.0	0.03	0.08	0.09	0.01	0.07	0.07	0.05	0.09	0.08	0.06
	2/326	10.55	0.10	0.08	0.08	0.08	0.04	0.07	0.08	0.05	0.08	0.08	0.09	0.07	0.08
	3/425	10.74	0.04	0.11	0.13	0.10	0.08	0.12	0.12	0.10	0.12	0.11	0.01	0.00	0.09
Spurlock	1/300	11.31	0.08	0.08	0.08	0.06	0.04	0.06	0.06	0.06	0.06	0.00	0.06	0.06	0.06
Total			1.83	1.41	1.39	1.29	1.24	1.62	1.71	1.67	1.36	1.31	1.50	1.57	1.50

TABLE 5-22. GROUP I - MONTHLY GASEOUS HCl MASS EMISSION RATE
EMISSION FACTOR = 32.32 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly gaseous HCl emissions, kg/h												Average gaseous HCl yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	12.35	8.03	6.25	5.41	9.36	3.69	1.15	0.00	1.09	0.00	0.14	1.52	4.54	3.43
	4/69	13.31	5.32	4.55	6.22	1.01	1.35	0.53	0.00	3.56	0.68	0.00	3.35	3.83	2.53
	5/71	12.85	6.40	0.00	1.72	0.30	0.00	0.00	0.91	6.12	0.69	0.00	0.61	0.25	1.42
	6/71	13.00	4.30	0.00	0.57	0.00	2.46	0.76	0.29	5.43	1.00	0.00	0.00	0.25	1.25
Beckjord	1/115	11.28	36.12	34.64	36.00	30.59	34.40	30.84	27.03	28.38	30.34	30.34	29.36	27.27	31.28
	2/112.5	11.31	29.45	29.93	31.38	28.73	27.17	27.41	24.04	24.40	25.85	26.69	17.07	13.83	25.50
	3/125	11.27	25.55	39.28	42.86	35.69	32.47	38.32	25.79	37.13	26.14	16.00	16.24	34.98	30.87
Miami Fort	5/100	10.72	0.71	14.97	18.71	8.49	23.76	18.51	5.46	0.00	0.00	11.33	15.67	12.94	10.88
Tanners Creek	1/150	10.80	28.86	32.01	34.92	35.65	26.92	0.00	26.31	25.95	22.31	38.20	29.35	34.20	27.89
	2/150	10.82	35.30	40.70	36.14	28.09	46.34	42.98	16.81	12.25	23.65	35.78	29.54	30.86	31.54
	3/150	10.64	68.67	60.35	44.33	44.21	67.30	51.90	43.09	37.50	40.85	45.70	37.75	43.46	48.74
Cane Run	1/112.5	11.71	42.99	37.26	22.66	24.60	21.20	6.04	0.00	21.56	6.95	0.00	2.84	1.23	15.61
	2/112.5	11.28	31.06	30.38	7.79	16.10	19.10	12.60	15.61	15.61	6.79	12.12	0.00	0.00	13.93
Total			322.75	330.32	288.71	262.82	300.15	231.04	185.34	218.99	185.24	216.30	183.30	207.63	244.87

TABLE 5-23. GROUP II - MONTHLY GASEOUS HCl MASS EMISSION RATE
EMISSION FACTOR = 41.223¹ mg/MJ
= 0.198² mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly gaseous HCl emissions, kg/h												Average gaseous HCl yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	12.54	65.97	70.61	71.97	65.78	52.43	29.21	51.27	76.03	66.75	60.55	54.75	53.59	59.91
	5/244	10.23	68.42	78.91	102.78	94.88	108.86	71.46	67.20	73.29	74.50	89.40	66.75	82.71	81.60
Miami Fort	6/168	9.63	64.72	60.33	62.23	59.01	64.58	42.90	57.84	66.63	58.87	38.37	0.0	2.34	48.15
	1/225	10.24	66.21	72.70	66.21	74.00	80.49	76.60	0.00	22.07	80.49	74.00	33.09	88.28	65.34
Clifty Creek	2/225	10.14	74.25	75.58	67.62	80.88	31.82	2.65	79.55	79.55	86.18	90.16	84.86	88.83	70.16
	3/225	10.23	78.15	89.52	42.63	4.26	75.31	75.31	93.78	86.68	88.10	90.94	75.31	82.42	73.54
Gallagher	4/225	10.23	30.89	0.00	59.20	74.65	90.09	83.66	78.51	64.35	77.22	66.93	83.66	70.79	65.00
	5/225	10.19	86.74	82.79	88.05	82.79	88.05	78.85	84.11	81.48	80.17	86.74	67.02	86.74	82.79
Cane Run	6/225	10.22	74.21	66.40	87.23	84.63	83.54	82.03	82.03	55.99	0.00	50.78	84.63	76.82	70.53
	1/150	11.30	7.47	0.00	0.00	0.00	0.00	1.25	24.90	32.38	31.13	29.89	22.41	26.15	14.63
Total	2/150	10.59	17.40	42.26	42.26	39.53	31.07	36.05	38.53	26.10	29.83	32.32	28.59	32.32	32.94
	3/150	10.50	44.75	39.78	36.05	39.78	31.07	0.00	13.67	31.07	31.07	36.05	38.53	36.05	31.49
Total	4/150	11.54	36.07	2.49	0.00	0.00	9.95	29.85	36.07	34.83	29.85	24.88	33.58	34.83	22.70
	3/147	11.36	43.70	44.11	28.86	26.79	32.98	19.79	14.02	33.39	26.38	7.42	16.90	17.31	25.97
Total	4/178	11.12	0.00	0.00	0.00	0.00	0.00	0.08	0.27	0.30	0.07	0.10	0.17	0.14	0.09
	5/183	10.96	0.22	0.18	0.21	0.13	0.09	0.21	0.19	0.21	0.16	0.20	0.11	0.18	0.17
Total			759.17	726.66	755.30	726.11	785.39	629.90	721.94	764.35	760.77	778.73	740.36	779.50	745.01

¹This value used for power plants using an ESP as their only emission control device.
²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

TABLE 5-24. GROUP III - MONTHLY GASEOUS HCl MASS EMISSION RATE
EMISSION FACTOR = 43.6571 mg/MJ
= 0.8202 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly gaseous HCl emissions, kg/h												Average gaseous HCl yearly emis- sion rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	11.02	109.02	0.00	0.00	0.00	23.99	70.31	135.82	139.79	54.92	156.66	155.34	99.59	78.78
Stuart	1/610	10.67	223.76	175.63	197.15	160.95	27.04	197.01	199.48	218.09	81.57	244.26	157.32	228.41	175.89
	2/610	10.77	174.34	140.33	165.02	219.14	132.34	203.47	215.15	192.67	110.61	220.62	212.49	171.97	179.83
	3/610	10.07	174.42	161.82	172.60	78.81	213.61	165.32	202.28	194.02	164.90	178.06	127.24	207.17	170.02
	4/610	9.85	222.85	171.64	186.99	72.14	228.85	163.54	218.80	215.59	211.54	62.10	211.40	221.59	182.25
Miami Fort	7/500	10.79	155.15	79.06	178.58	165.03	122.68	130.16	174.21	143.43	151.48	78.91	190.44	200.18	147.44
	8/500	10.43	173.80	143.79	22.81	150.15	146.15	134.39	124.02	132.60	148.77	145.73	19.22	0.00	111.79
Tanners Creek	4/500	10.42	145.47	94.96	98.13	106.94	34.82	114.65	173.00	142.03	115.06	49.96	181.26	170.94	118.94
Ghent	1/511	10.54	180.94	175.48	159.06	121.45	159.62	195.16	185.51	198.62	42.52	130.52	200.79	199.50	162.43
	2/511	10.55	245.78	183.17	115.12	119.22	78.25	25.33	93.53	82.52	149.64	34.65	31.64	105.14	105.30
Cane Run	6/277	10.96	1.75	1.16	1.33	1.19	1.48	1.44	1.30	1.56	1.20	0.53	1.20	1.70	1.32
Mill Creek	1/335	10.51	1.92	0.57	0.00	0.67	1.92	2.01	0.18	1.67	1.58	1.18	2.07	1.97	1.43
	2/326	10.55	2.26	1.93	1.90	1.80	1.01	1.70	1.86	1.26	1.85	1.77	2.10	1.74	1.77
	3/425	10.74	0.98	2.61	3.13	2.28	1.96	2.83	2.92	2.30	2.75	2.59	0.17	0.00	2.04
Spurluck	1/300	11.31	101.11	95.66	94.41	74.42	50.70	72.70	80.04	77.84	68.72	0.00	71.68	78.37	72.14
Total			1913.55	1427.81	1396.23	1274.19	1224.42	1480.02	1808.10	1743.99	1307.11	1307.54	1564.36	1688.27	1511.37

¹This value used for power plants using an ESP as their only emission control device.
²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

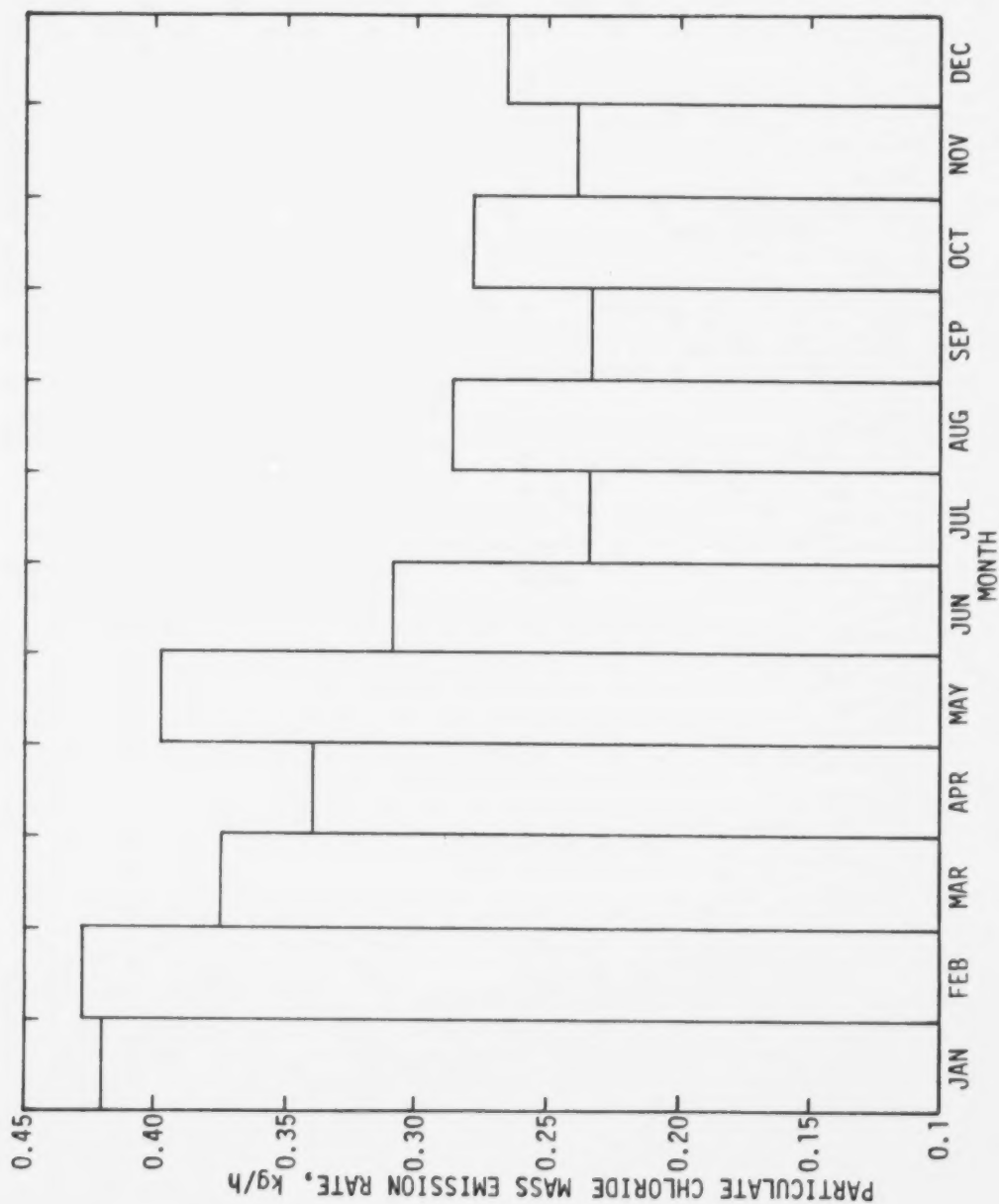


Figure 5-27. Group I monthly particulate chloride mass emissions.

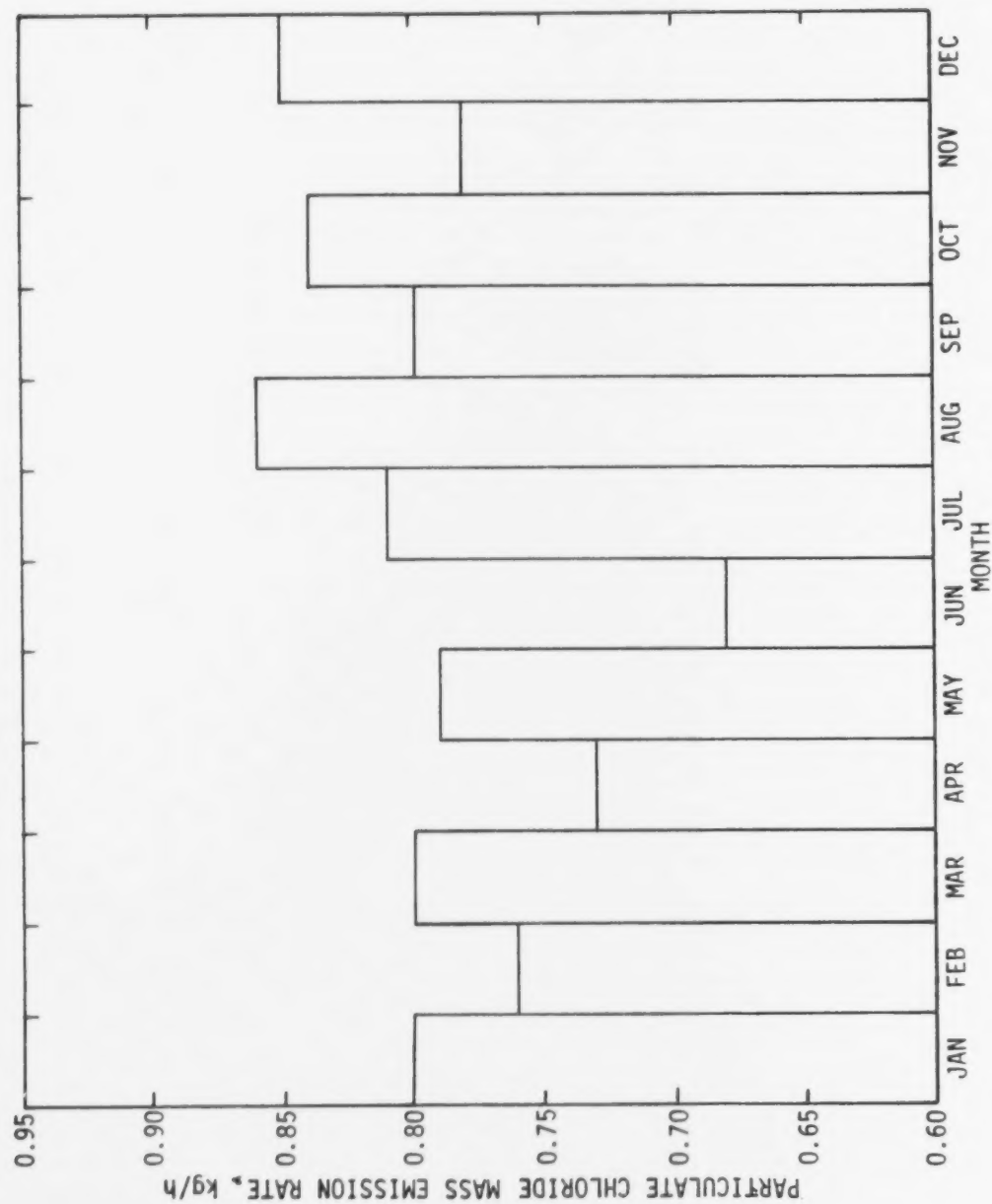


Figure 5-28. Group II monthly particulate chloride mass emissions.

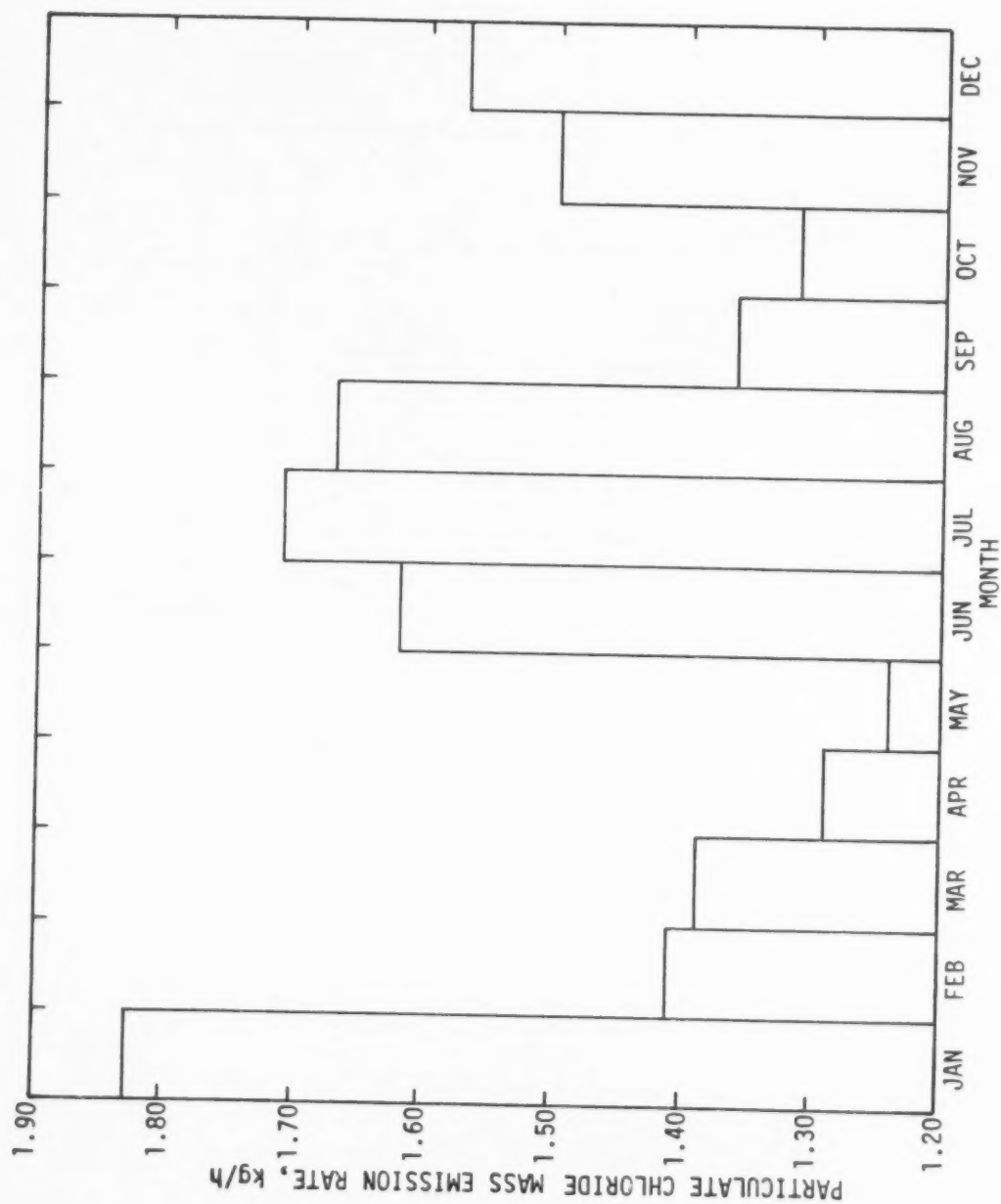


Figure 5-29. Group III monthly particulate chloride emissions.

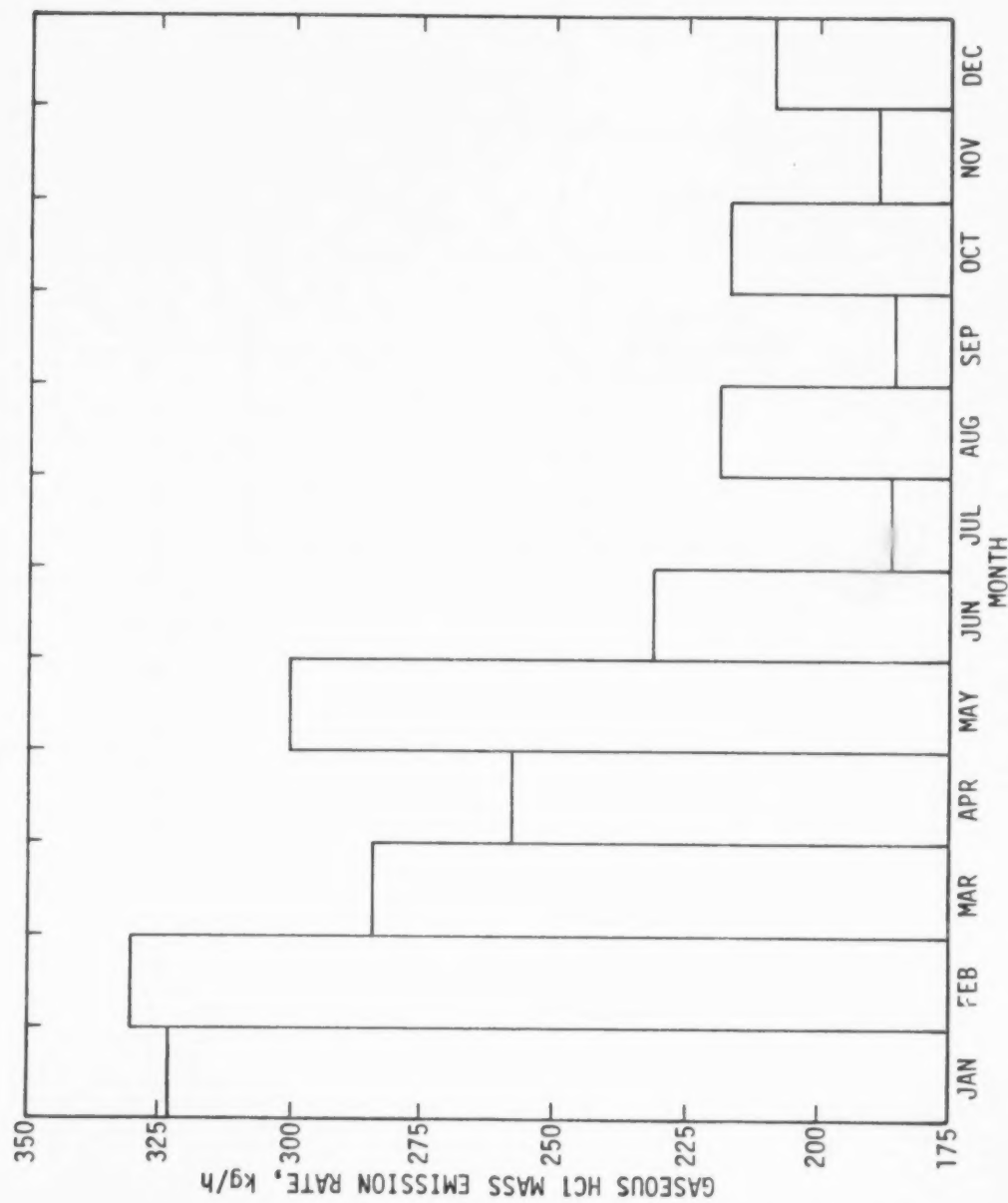


Figure 5-30. Group I monthly HCl mass emissions.

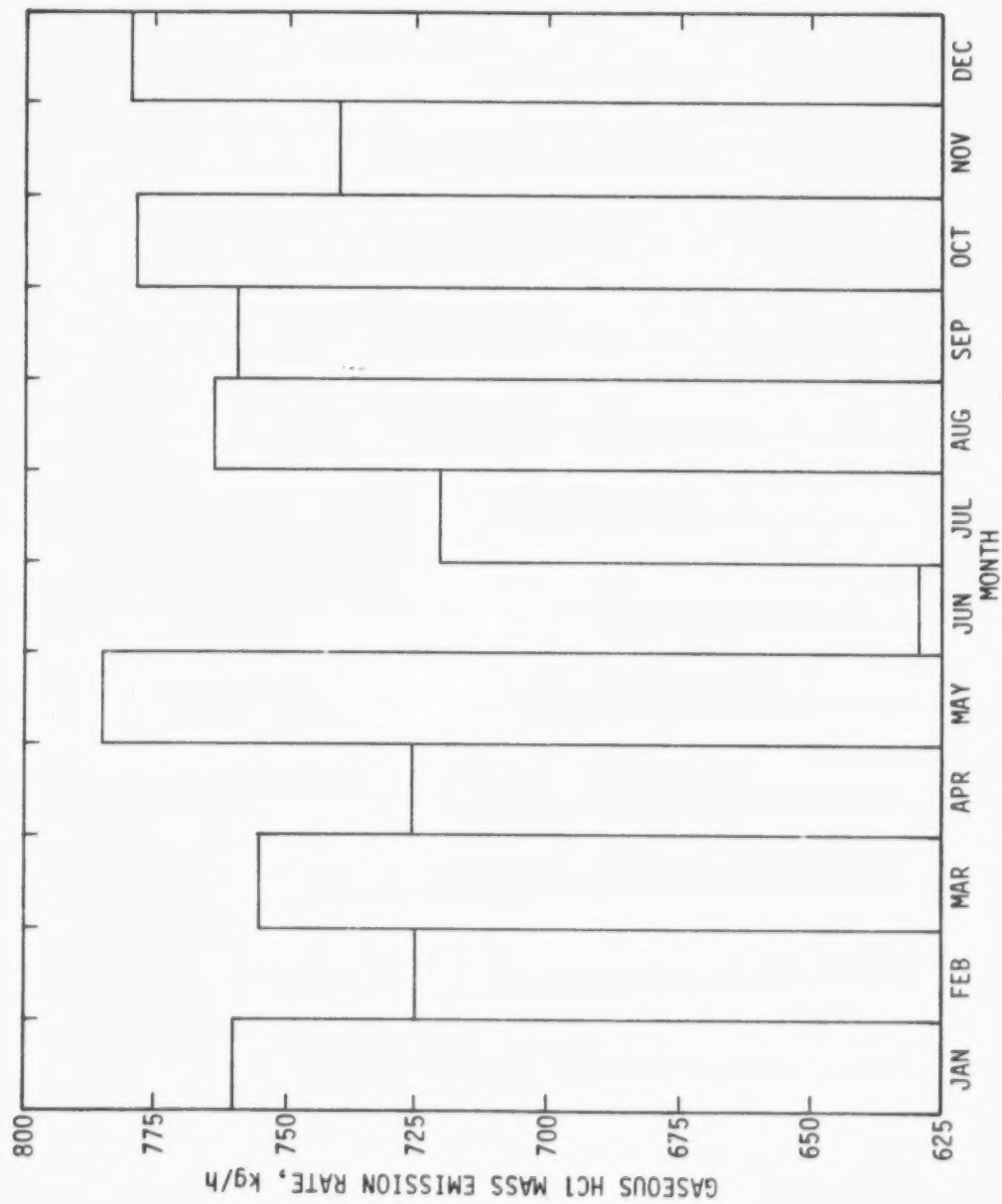


Figure 5-31. Group II monthly gaseous HCl emissions.

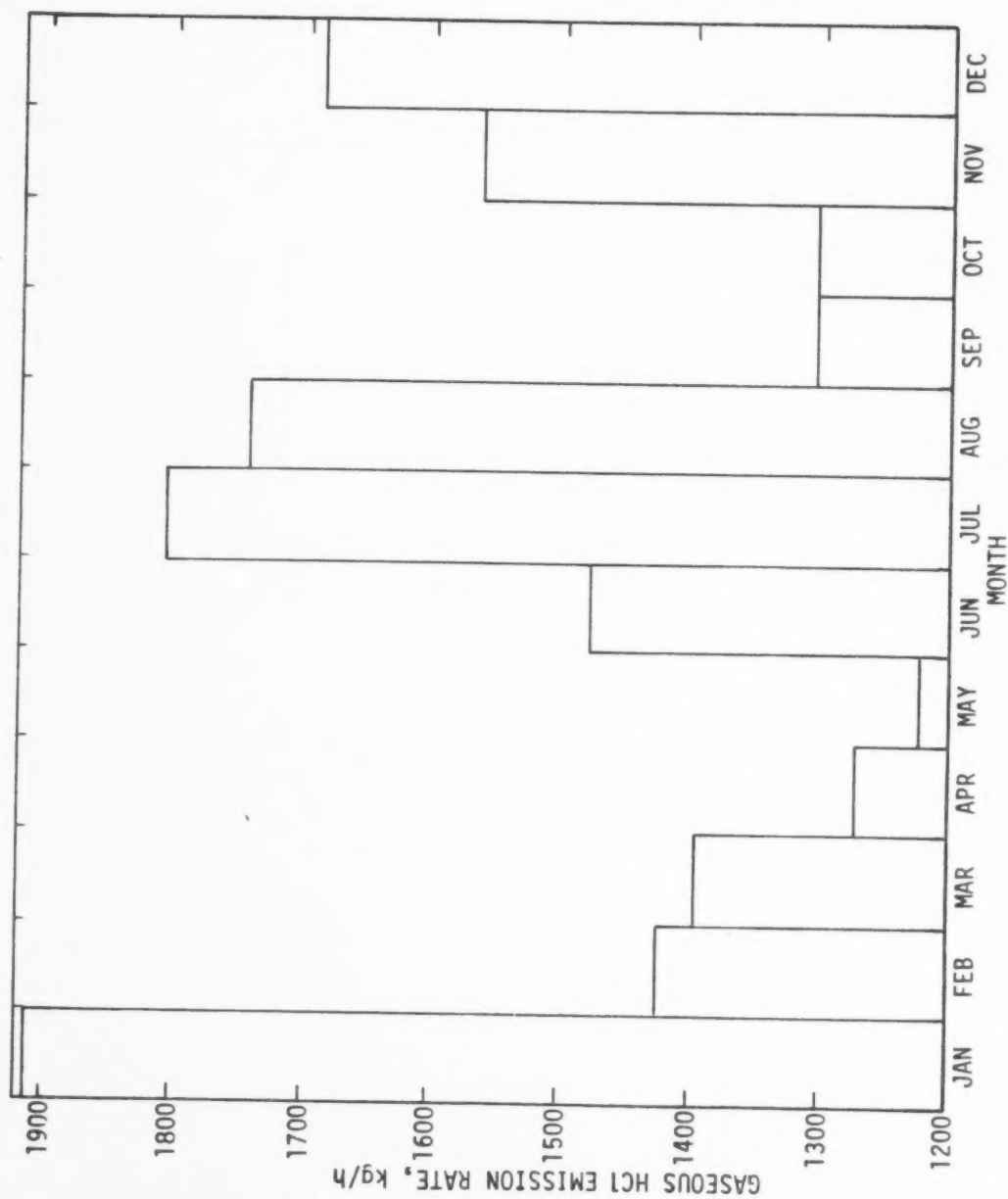


Figure 5-32. Group.III monthly gaseous HCl emissions.

PARTICULATE FLUORIDE AND GASEOUS HF

For power plants in Groups II and III, the particulate fluoride emission rates were calculated using an average of the emission factors determined for the two plants tested in each group. This was done since the emission data for the two different emission control methods compared closely for both groups.

The total yearly average particulate fluoride mass emission rate for all of the power plants operating in the study region is 3.2 kg/h. The gaseous HF total mass emission rate is 213 kg/h. Figures 5-33 and 5-34 present the total monthly particulate fluoride and gaseous HF mass emission rates. The yearly average particulate fluoride mass emission rates for plants in Groups I, II and III are 0.28, 0.75, and 2.1 kg/h, respectively.

The yearly average gaseous HF mass emission rates for powerplants in Groups I, II, and III are 23, 60, and 130 kg/h, respectively. Tables 5-25 through 5-30 present the yearly average particulate fluoride and gaseous HF mass emission rates on a group basis for each plant operating in the study region. The average monthly particulate fluoride and gaseous HF mass emission rates for Groups I, II, and III are presented in Figures 5-35 through 5-40.

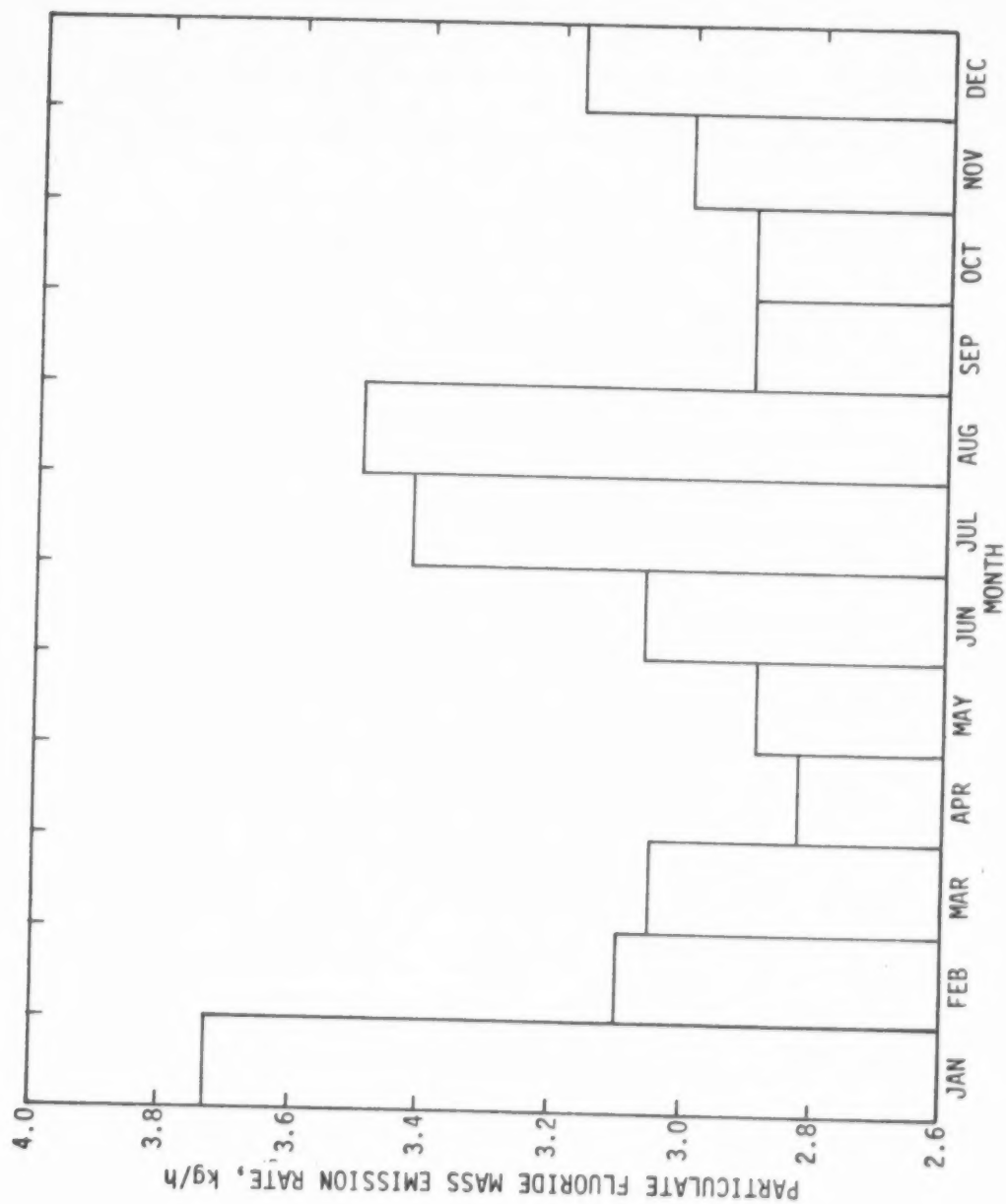


Figure 5-33. Total monthly particulate fluoride mass emissions.

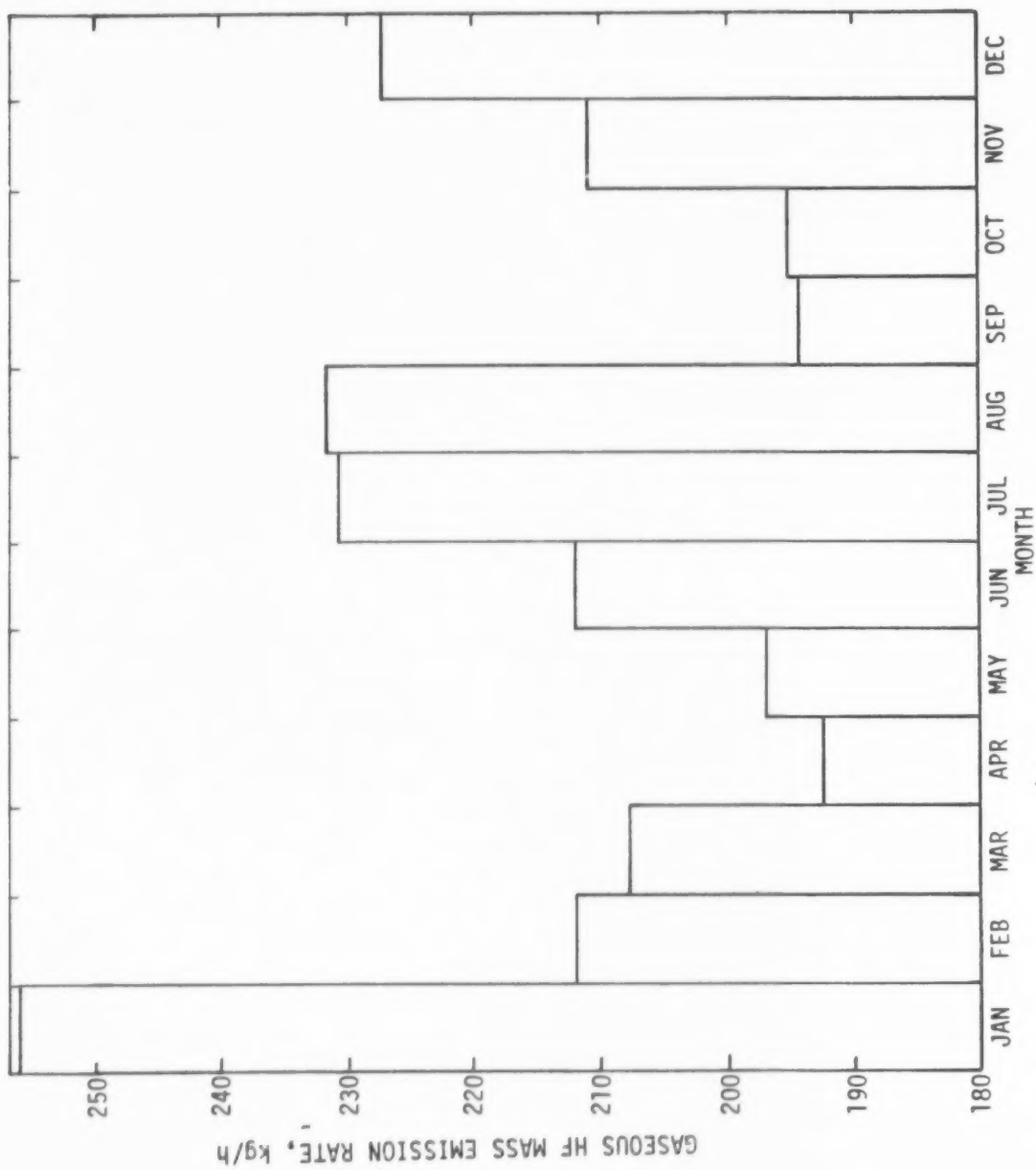


Figure 5-34. Total monthly gaseous HF mass emissions.

TABLE 5-25. GROUP I - MONTHLY PARTICULATE FLUORIDE MASS EMISSION RATE
EMISSION FACTOR = 0.037 mg/MJ

Plant	Unit/ size, MH	Heat rate, MJ/kWh	Monthly particulate fluoride emissions, kg/h												Average particulate fluoride yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	12.35	0.009	0.007	0.006	0.011	0.004	0.001	0.000	0.001	0.000	0.000	0.002	0.005	0.004
	4/69	13.31	0.006	0.005	0.007	0.001	0.002	0.001	0.000	0.005	0.001	0.000	0.004	0.004	0.003
	5/71	12.85	0.007	0.000	0.002	0.000	0.000	0.000	0.001	0.007	0.001	0.000	0.001	0.000	0.002
	6/71	13.00	0.005	0.000	0.001	0.000	0.003	0.001	0.000	0.006	0.001	0.000	0.000	0.000	0.001
Beckjord	1/115	11.28	0.041	0.040	0.041	0.035	0.039	0.035	0.031	0.032	0.035	0.035	0.034	0.031	0.036
	2/115	11.31	0.034	0.034	0.036	0.033	0.031	0.031	0.028	0.028	0.030	0.031	0.020	0.016	0.029
	3/125	11.27	0.029	0.045	0.049	0.041	0.037	0.044	0.030	0.043	0.030	0.018	0.019	0.040	0.035
Miami Fort	5/100	10.72	0.001	0.017	0.021	0.010	0.027	0.021	0.006	0.000	0.000	0.013	0.018	0.015	0.012
Tanners Creek	1/150	10.80	0.033	0.037	0.040	0.041	0.031	0.000	0.030	0.030	0.026	0.044	0.034	0.039	0.032
	2/150	10.82	0.040	0.047	0.041	0.032	0.053	0.049	0.019	0.014	0.027	0.041	0.034	0.035	0.036
	3/215	10.64	0.079	0.069	0.051	0.051	0.077	0.059	0.049	0.043	0.047	0.052	0.043	0.050	0.056
Cane Run	1/112.5	11.71	0.049	0.043	0.026	0.028	0.024	0.007	0.000	0.025	0.008	0.000	0.003	0.001	0.018
	2/112.5	11.28	0.036	0.035	0.009	0.018	0.022	0.014	0.018	0.013	0.008	0.014	0.000	0.000	0.016
Total			0.369	0.379	0.330	0.301	0.350	0.263	0.212	0.252	0.214	0.248	0.212	0.236	0.280

TABLE 5-26. GROUP II - MONTHLY PARTICULATE FLUORIDE MASS EMISSION RATE
EMISSION FACTOR = 0.0385 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly particulate fluoride emissions, kg/h												Average particulate fluoride yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	12.54	0.06	0.07	0.07	0.06	0.05	0.03	0.05	0.07	0.06	0.06	0.05	0.05	0.06
	5/244	10.23	0.06	0.07	0.10	0.09	0.10	0.07	0.06	0.07	0.07	0.08	0.06	0.08	0.08
Miami Fort	6/168	9.63	0.06	0.06	0.06	0.06	0.06	0.04	0.05	0.06	0.06	0.04	0.00	0.00	0.04
	1/225	10.24	0.06	0.07	0.06	0.07	0.08	0.07	0.00	0.10	0.08	0.07	0.08	0.08	0.06
Clifty Creek	2/225	10.14	0.07	0.07	0.06	0.08	0.03	0.0	0.07	0.07	0.08	0.08	0.08	0.08	0.07
	3/225	10.23	0.07	0.08	0.04	0.00	0.07	0.07	0.09	0.08	0.08	0.08	0.07	0.08	0.07
	4/225	10.23	0.03	0.00	0.06	0.07	0.08	0.08	0.07	0.06	0.07	0.06	0.08	0.07	0.06
	5/225	10.19	0.08	0.08	0.08	0.08	0.08	0.07	0.08	0.08	0.07	0.08	0.06	0.08	0.08
Gallagher	6/225	10.22	0.07	0.06	0.08	0.03	0.08	0.08	0.08	0.05	0.00	0.05	0.03	0.07	0.07
	1/150	11.30	0.01	0.00	0.00	0.00	0.00	0.00	0.02	0.03	0.03	0.03	0.02	0.02	0.01
	2/150	10.59	0.02	0.04	0.04	0.04	0.03	0.03	0.04	0.02	0.03	0.03	0.03	0.03	0.03
	3/150	10.50	0.04	0.04	0.03	0.04	0.03	0.00	0.01	0.03	0.03	0.03	0.04	0.03	0.03
Cane Run	4/150	11.54	0.03	0.00	0.00	0.00	0.01	0.03	0.03	0.03	0.03	0.02	0.03	0.03	0.02
	3/147	11.36	0.04	0.04	0.02	0.02	0.03	0.02	0.02	0.01	0.03	0.02	0.01	0.01	0.02
	4/178	11.12	0.00	0.00	0.00	0.00	0.00	0.01	0.05	0.06	0.01	0.02	0.03	0.03	0.02
	5/183	10.96	0.04	0.03	0.04	0.02	0.02	0.04	0.04	0.04	0.03	0.04	0.02	0.04	0.03
Total			0.74	0.71	0.74	0.71	0.75	0.64	0.76	0.86	0.76	0.79	0.74	0.78	0.75

TABLE 5-27. GROUP III - MONTHLY PARTICULATE FLUORIDE MASS EMISSION RATE
EMISSION FACTOR = 0.050 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly particulate fluoride emissions, kg/h												Average particulate fluoride yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	11.02	0.12	0.00	0.00	0.00	0.03	0.08	0.16	0.16	0.06	0.18	0.18	0.11	0.09
Stuart	1/610	10.67	0.26	0.20	0.23	0.18	0.03	0.23	0.21	0.25	0.09	0.28	0.18	0.26	0.20
	2/610	10.77	0.20	0.16	0.19	0.25	0.15	0.23	0.25	0.22	0.13	0.25	0.24	0.20	0.21
	3/610	10.07	0.20	0.19	0.20	0.09	0.24	0.19	0.23	0.22	0.19	0.27	0.15	0.24	0.19
	4/610	9.85	0.25	0.20	0.21	0.08	0.26	0.19	0.25	0.25	0.24	0.07	0.24	0.25	0.21
Miami Fort	7/500	10.79	0.18	0.09	0.20	0.19	0.14	0.15	0.20	0.16	0.17	0.09	0.22	0.23	0.17
	8/500	10.43	0.20	0.16	0.03	0.17	0.17	0.15	0.14	0.15	0.17	0.17	0.02	0.00	0.13
Tanners Creek	4/500	10.42	0.17	0.11	0.11	0.12	0.04	0.13	0.20	0.16	0.13	0.06	0.21	0.20	0.14
	1/511	10.54	0.21	0.20	0.18	0.14	0.18	0.22	0.21	0.23	0.05	0.15	0.23	0.23	0.19
Cane Run	2/511	10.55	0.28	0.21	0.13	0.14	0.09	0.03	0.11	0.09	0.17	0.04	0.04	0.12	0.12
	6/277	10.96	0.11	0.07	0.08	0.07	0.09	0.09	0.08	0.10	0.07	0.03	0.07	0.10	0.08
M111 Creek	1/335	10.51	0.12	0.03	0.00	0.04	0.12	0.12	0.01	0.10	0.10	0.07	0.13	0.12	0.09
	2/326	10.55	0.14	0.12	0.12	0.11	0.06	0.10	0.11	0.08	0.11	0.11	0.13	0.11	0.11
	3/425	10.74	0.06	0.16	0.19	0.14	0.12	0.17	0.18	0.14	0.17	0.16	0.10	0.00	0.12
Spurlock	1/300	11.31	0.12	0.11	0.11	0.09	0.06	0.08	0.09	0.09	0.08	0.00	0.08	0.09	0.08
Total			2.62	2.01	1.98	1.81	1.78	2.16	2.45	2.40	1.93	1.86	2.04	2.15	2.13

TABLE 5-28. GROUP I - MONTHLY GASEOUS HF MASS EMISSION RATE
EMISSION FACTOR = 3.01 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly gaseous HF emissions, kg/h												Average gaseous HF yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Paddy's Run	3/69	12.35	0.743	0.582	0.504	0.872	0.343	0.107	0.000	0.102	0.000	0.013	0.141	0.423	0.320
	4/69	13.31	0.496	0.424	0.579	0.094	0.126	0.050	0.000	0.332	0.063	0.000	0.312	0.356	0.236
	5/71	12.85	0.595	0.000	0.160	0.028	0.000	0.000	0.085	0.570	0.064	0.000	0.056	0.023	0.132
Beckford	6/71	13.00	0.400	0.000	0.053	0.000	0.228	0.070	0.027	0.506	0.092	0.000	0.000	0.023	0.117
	1/115	11.28	3.360	3.230	3.350	2.850	3.200	2.870	2.520	2.640	2.870	2.830	2.730	2.540	2.910
	2/112.5	11.31	2.740	2.790	2.920	2.680	2.530	2.550	2.240	2.270	2.410	2.490	1.590	1.290	2.370
Miami Fort	3/125	11.27	2.380	3.660	3.990	3.320	3.020	3.570	2.400	3.460	2.430	1.490	1.510	3.260	2.870
	5/100	10.72	0.070	1.390	1.740	0.790	2.210	1.720	0.510	0.000	0.000	1.050	1.460	1.210	1.010
Tanners Creek	1/150	10.80	2.690	2.980	3.250	3.320	2.510	0.000	2.450	2.420	2.080	3.560	2.730	3.180	2.600
	2/150	10.82	3.290	3.790	3.370	2.620	4.320	4.000	1.570	1.140	2.200	3.330	2.750	2.870	2.940
	3/215	10.64	6.400	5.620	4.130	4.120	6.270	4.870	4.010	3.490	3.800	4.260	3.520	4.050	4.540
Cane Run	1/112.5	11.71	4.000	3.470	2.110	2.290	1.970	0.560	0.000	2.010	0.650	0.000	0.250	0.110	1.450
	2/112.5	11.28	2.890	2.830	0.730	1.590	1.780	1.170	1.450	1.450	0.630	1.130	0.000	0.000	1.300
Total			30.060	30.770	26.890	24.470	28.510	21.500	17.260	20.390	17.250	20.150	17.060	19.340	22.800

TABLE 5-29. GROUP II - MONTHLY GASEOUS HF MASS EMISSION RATE
EMISSION FACTOR = 3.301 mg/MJ
= 0.0972 mg/MJ

Plant	Unit/ size, MN	Heat rate, MJ/kWh	Monthly gaseous HF emissions, kg/h												Average gaseous HF yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	4/163	12.54	5.28	5.65	5.76	5.27	4.20	2.34	4.10	6.09	5.34	4.85	4.38	4.29	4.80
	5/244	10.23	5.48	6.32	8.23	7.60	8.71	5.72	5.38	5.87	5.96	7.16	5.34	6.62	6.53
Miami Fort	6/168	9.63	5.18	4.83	4.98	4.72	5.17	3.43	4.63	5.33	4.71	3.07	0.00	0.19	3.85
Clifty Creek	1/225	10.24	5.30	5.92	5.30	5.92	6.44	6.13	0.00	1.77	6.44	5.92	6.65	7.07	5.23
	2/225	10.14	5.94	6.05	5.41	6.47	2.55	0.21	6.37	6.37	6.90	7.22	6.79	7.11	5.62
	3/225	10.23	6.26	7.17	3.41	0.34	6.03	6.03	7.51	6.94	7.05	7.28	6.03	6.60	5.89
	4/225	10.23	2.47	0.00	4.74	5.98	7.21	6.70	6.28	5.15	6.18	5.36	6.70	5.67	5.20
	5/225	10.19	6.94	6.63	7.05	6.63	7.05	6.31	6.73	6.52	6.42	6.94	5.37	6.94	6.63
	6/225	10.22	5.94	5.32	6.98	6.77	7.09	6.57	6.57	4.43	0.00	4.06	6.77	6.15	5.65
Gallagher	1/150	11.30	0.60	0.00	0.00	0.00	0.00	0.10	1.99	2.59	2.49	2.39	1.79	2.09	1.17
	2/150	10.59	1.39	3.38	3.38	3.08	2.49	2.89	3.08	2.09	2.39	2.59	2.29	2.59	2.64
	3/150	10.50	3.58	3.18	2.89	3.18	2.49	0.0	1.09	2.49	2.49	2.89	3.08	2.89	2.52
	4/150	11.54	2.89	0.20	0.0	0.0	0.80	2.39	2.89	2.79	2.39	1.99	2.69	2.79	1.82
Cane Run	3/147	11.36	3.50	3.53	2.31	2.15	2.64	1.58	1.12	2.67	2.11	0.59	1.35	1.39	2.08
	4/178	11.12	0.00	0.00	0.00	0.00	0.00	0.04	0.13	0.15	0.03	0.05	0.08	0.07	0.05
	5/183	10.96	0.11	0.09	0.10	0.06	0.04	0.10	0.09	0.10	0.08	0.10	0.06	0.09	0.09
Total			60.86	58.17	60.54	58.17	62.91	50.54	57.96	61.40	60.98	62.46	59.37	62.55	59.77

¹ This value used for power plants using an ESP as their only emission control device.

² This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

TABLE 5-30. GROUP III - MONTHLY GASEOUS HF MASS EMISSION RATE
EMISSION FACTOR = 3.76^1 mg/MJ
= 0.0872 mg/MJ

Plant	Unit/ size, MW	Heat rate, MJ/kWh	Monthly gaseous HF emissions, kg/h												Average gaseous HF yearly emission rate, kg/h
			January	February	March	April	May	June	July	August	September	October	November	December	
Beckjord	6/460	11.02	9.39	0.00	0.00	0.00	2.07	6.06	11.70	12.04	4.73	13.49	13.38	8.58	6.79
Stuart	1/610	10.67	19.27	15.13	16.98	13.86	2.33	16.97	17.18	18.78	7.02	21.04	13.55	19.67	15.15
	2/610	10.77	15.01	12.09	14.21	18.87	11.40	17.52	18.52	16.59	9.53	19.00	18.30	14.81	15.49
	3/610	10.07	15.02	13.94	14.87	6.79	18.40	14.24	17.42	16.71	14.20	15.34	10.96	17.84	14.64
	4/610	9.85	19.17	14.77	16.09	6.21	19.69	14.07	18.82	18.55	18.20	5.34	18.19	19.06	15.68
Miami Fort	7/500	10.79	13.36	6.81	15.38	14.21	10.57	11.21	15.00	12.35	13.05	6.80	16.40	17.24	12.70
	8/500	10.43	14.97	12.38	1.96	12.93	12.59	11.57	10.68	11.42	12.81	12.55	1.66	0.00	9.63
Tanners Creek	4/500	10.42	12.53	8.18	8.45	9.21	3.00	9.87	14.90	12.23	9.91	4.30	15.61	14.72	10.24
	1/511	10.54	15.58	15.11	13.70	10.46	13.76	16.81	15.98	17.11	3.66	11.24	17.29	17.18	13.99
Ghent	2/511	10.55	21.14	15.73	9.91	10.27	6.74	14.79	8.06	7.11	12.89	2.98	2.72	9.05	9.07
	6/277	10.96	0.19	0.12	0.14	0.13	0.16	0.15	0.14	0.17	0.13	0.06	0.13	0.18	0.14
M111 Creek	1/335	10.51	0.20	0.06	0.00	0.07	0.20	0.21	0.02	0.18	0.17	0.12	0.22	0.21	0.15
	2/326	10.55	0.24	0.21	0.20	0.19	0.11	0.18	0.20	0.13	0.20	0.19	0.22	0.18	0.19
	3/425	10.74	0.10	0.28	0.33	0.24	0.21	0.30	0.31	0.24	0.29	0.28	0.02	0.00	0.22
Spurlock	1/300	11.31	8.71	8.24	8.13	6.41	4.37	6.26	6.89	6.70	5.92	0.00	6.17	6.75	6.21
Total			164.83	123.10	120.35	109.85	105.59	140.21	155.82	150.31	112.71	112.73	134.82	145.47	130.29

¹This value used for power plants using an ESP as their only emission control device.

²This value used to calculate emissions for power plants utilizing both a scrubber and an ESP to control emissions.

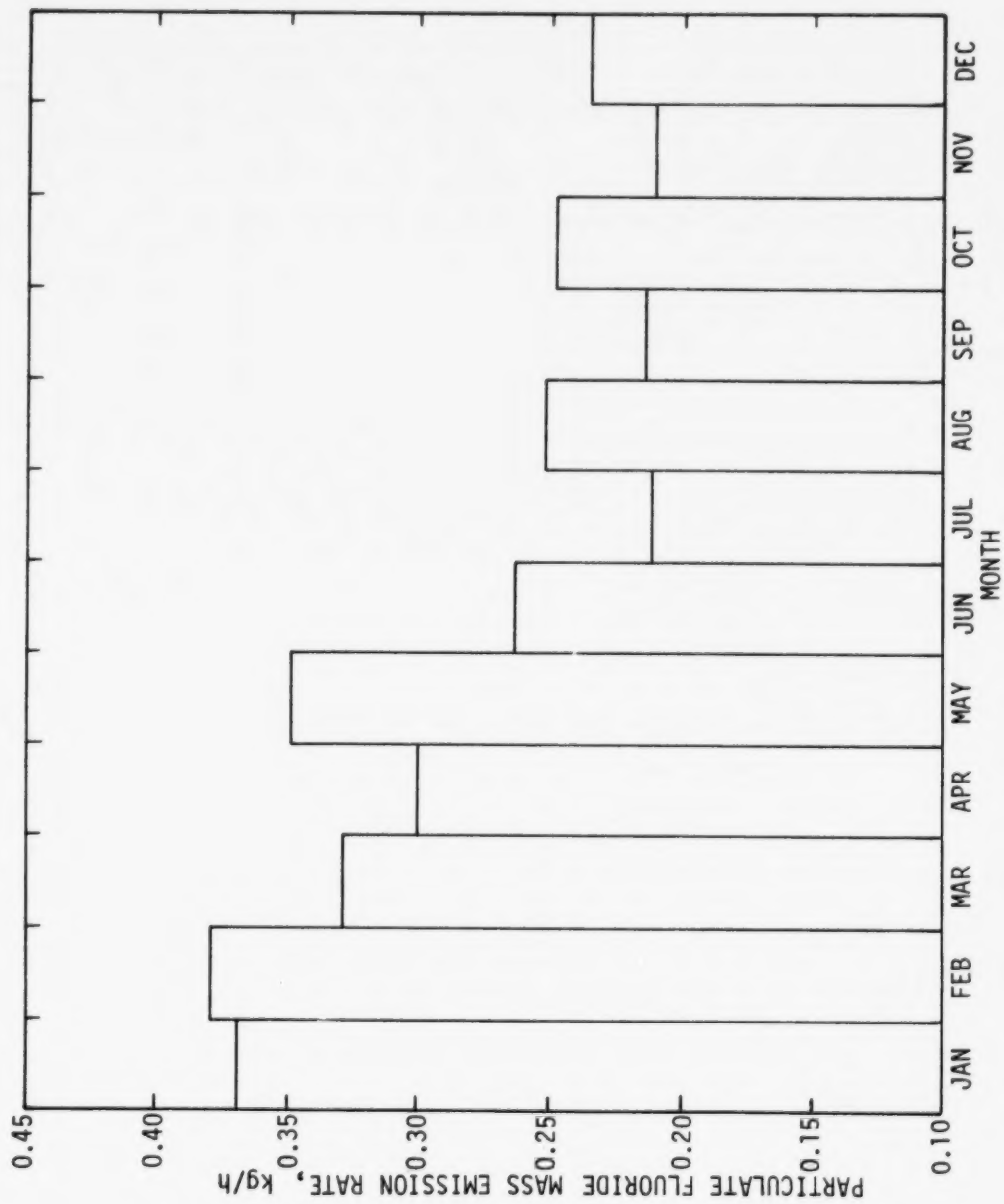


Figure 5-35. Group I monthly particulate fluoride mass emissions.

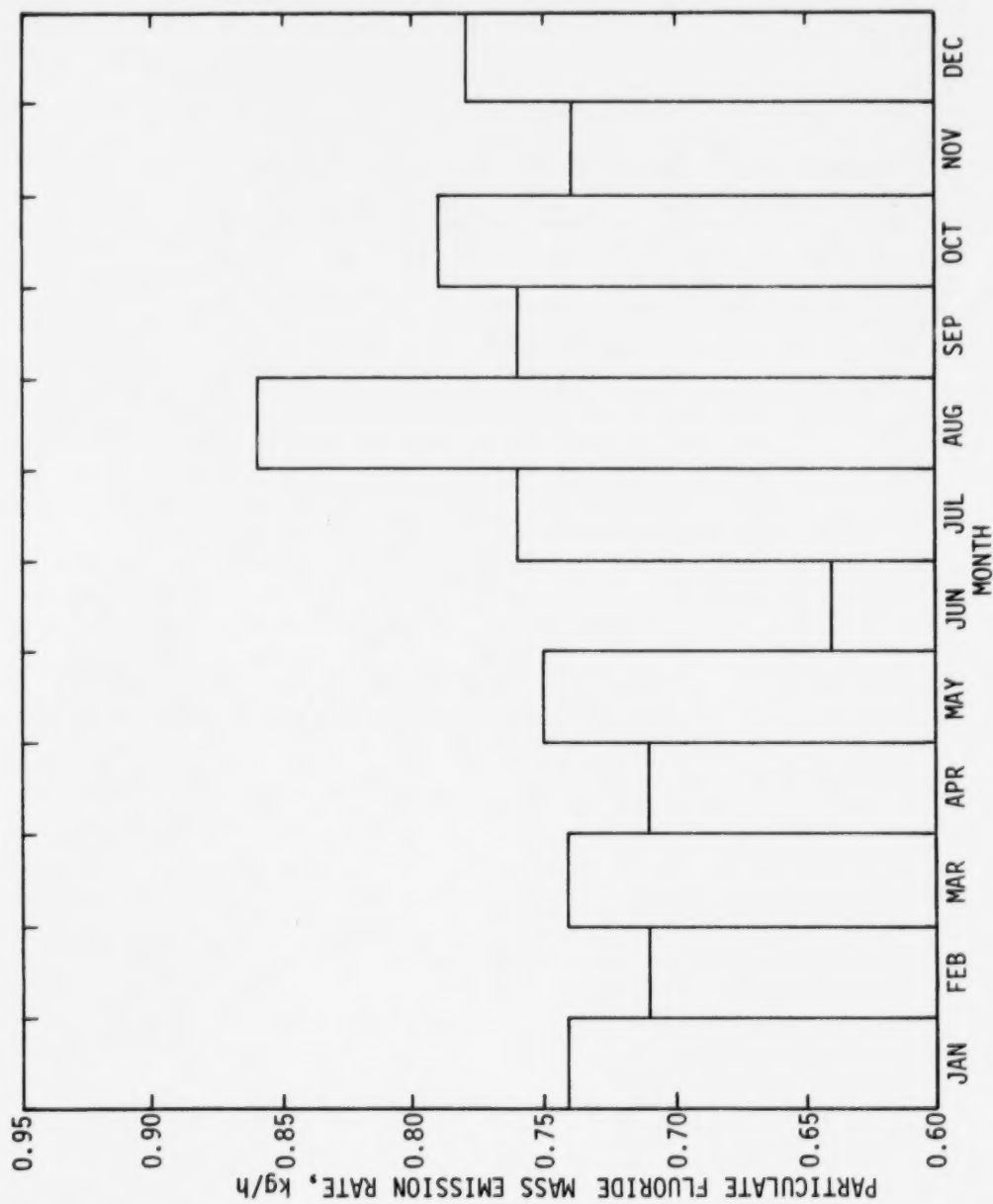


Figure 5-36. Group II monthly particulate fluoride mass emissions.

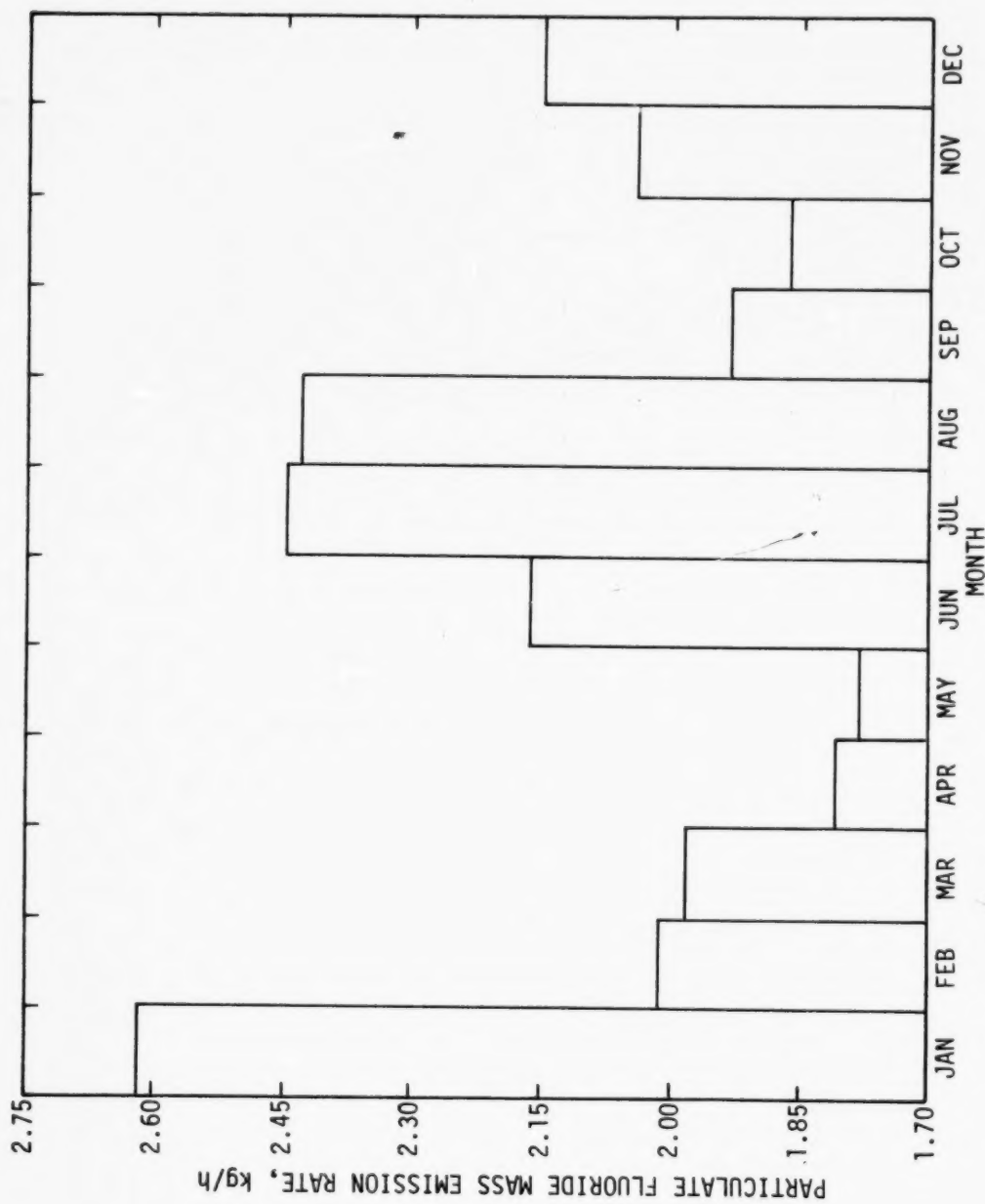


Figure 5-37. Group III monthly particulate fluoride emissions.

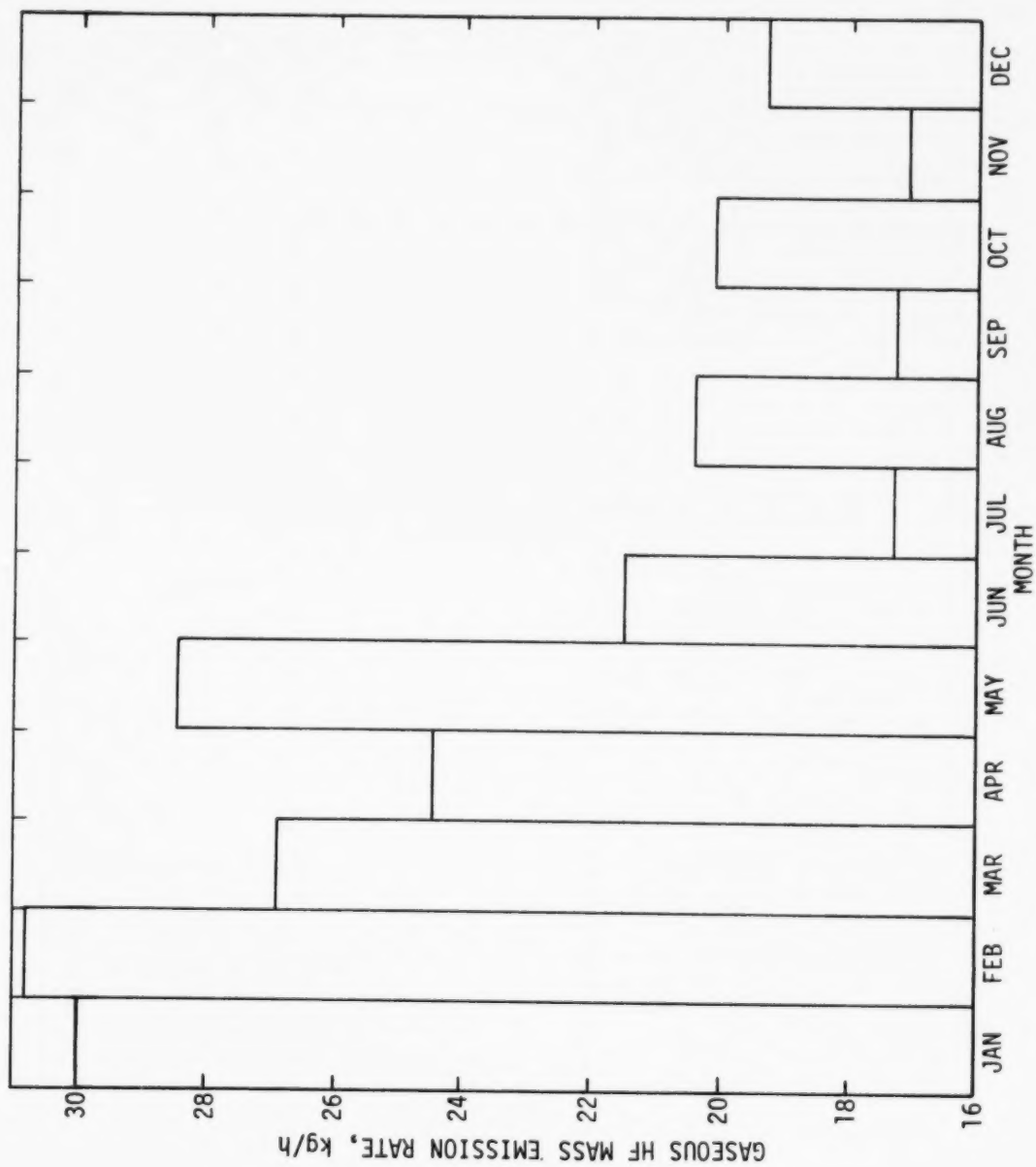


Figure 5-38. Group I monthly gaseous HF mass emissions.

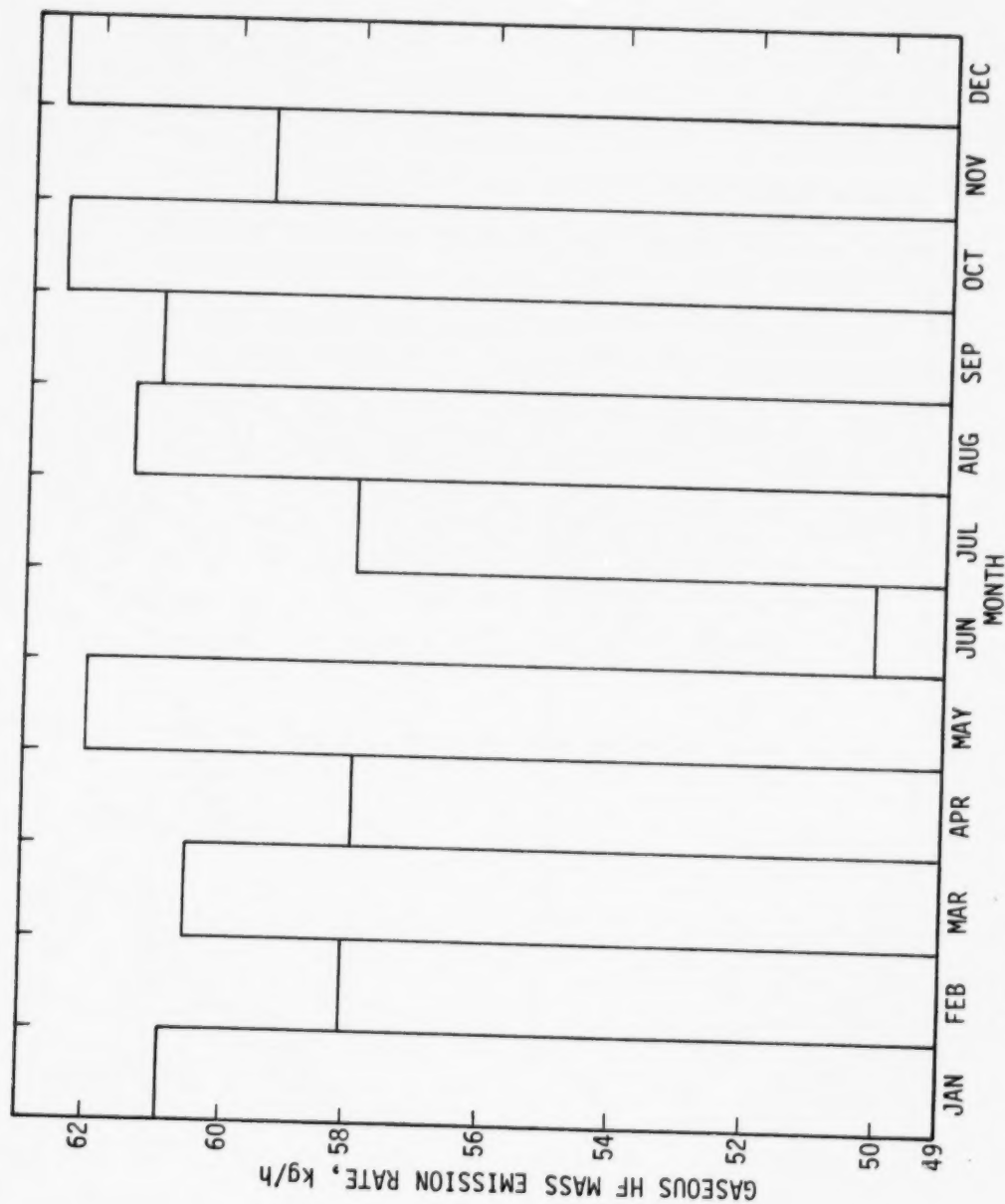


Figure 5-39. Group II monthly gaseous HF emissions.

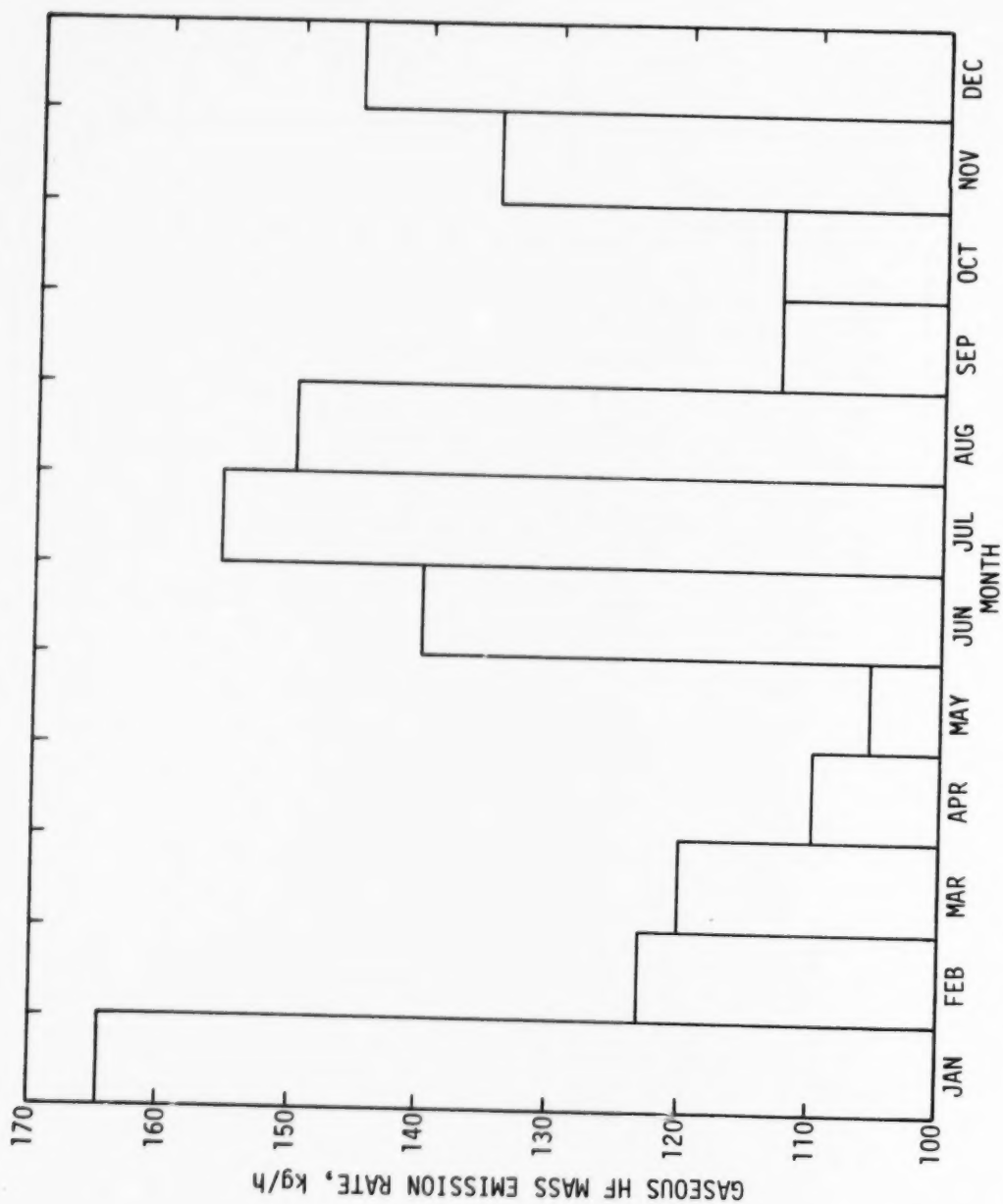


Figure 5-40. Group III monthly gaseous HF emissions.

SECTION 6

PROJECTED POLLUTANT MASS EMISSION RATES FROM PLANTS COMING ON LINE BY THE END OF 1983

As new power plant units come on line, an increase in the emission rate of pollutants will occur. Tables 6-1 and 6-2 present a projection of the power plant units scheduled to come on line by the end of 1983. It also projects an estimate of the percent sulfur and higher heating value for the type of coal that will most likely be burned at each new plant. Projections have also been made for the average boiler capacity factor to occur at each plant. These values are used with the expected emission factor based on the type of emission control device to be installed at the plant to project expected particulate and gaseous pollutant emission rates.

Figures 6-1 and 6-2 present the expected increases in particulate and gaseous pollutant emission rates for 1983.

Even though projections have been made that some existing power plant units may be taken off line by 1983, the projected emission rates for 1983 include all units now operating and those which are projected to come on line.

TABLE 6-1. PLANTS SCHEDULED TO COME ON LINE BY THE END OF 1983 AND THEIR PROJECTED PARTICULATE POLLUTANT MASS EMISSION RATES

Plant	Unit/ size	% S in coal ^a	HHV of coal ^b	Emission control method	Yearly particulate pollutants mass emission rates, kg/h			
					Filterable particulate	Particulate chloride	Particulate fluoride	Particulate sulfate
Killen	2/661	1.2	11.79	ESP	207.4	0.16	0.22	0.08
Spurlock	2/508	3.6	11.50	ESP and SO ₂ scrubber	153.6	0.12	0.16	0.56
East Bend	2/669	3.6	11.50	ESP and SO ₂ scrubber	202.7	0.15	0.22	0.56
Ghent	3/511	2.1	12.28	ESP	156.0	0.12	0.17	0.14
	4/511	2.1	12.28	ESP	156.0	0.12	0.17	0.14
Mill Creek	4/495	3.7	10.74	ESP and SO ₂ scrubber	149.0	0.11	0.16	0.61
Total particulate pollutant increase					1024.6	0.78	1.10	2.09

^aSulfur content of coal estimated from inhouse data.

^bHigher heating value of coal estimated from inhouse data.

TABLE 6-2. PLANTS SCHEDULED TO COME ON LINE BY THE END OF 1983 AND THEIR
PROJECTED GASEOUS POLLUTANT MASS EMISSION RATES

Plant	Unit/ size	% S in coal ^a	HHV of coal ^b	Emission control method	Yearly gaseous pollutants mass emission rates, kg/h					
					Gaseous HCl	Gaseous HF	Sulfur dioxide	Sulfuric acid	NO ₂	NO _x
Killen	2/661	1.2	11.79	ESP	194.0	16.7	3674	12.8	52.4	2255
Spurlock	2/508	3.6	11.50	ESP and scrubber	2.7	0.3	2972	63.4	17.3	2638
East Bend	2/669	3.6	11.50	ESP and scrubber	3.6	0.4	3920	83.7	22.8	3481
Ghent	3/511	2.1	12.28	ESP	145.8	12.6	4643	16.2	39.4	1696
	4/511	2.1	12.28	ESP	145.8	12.6	4643	16.2	39.4	1696
Mill Creek	4/495	3.7	10.74	ESP and scrubber	2.6	0.3	3171	67.7	16.8	2558
Total gaseous pollutant increase					494.5	42.8	23023	259.9	188.2	14324

^aSulfur content of coal estimated from inhouse data.

^bHigher heating value of coal estimated from inhouse data.

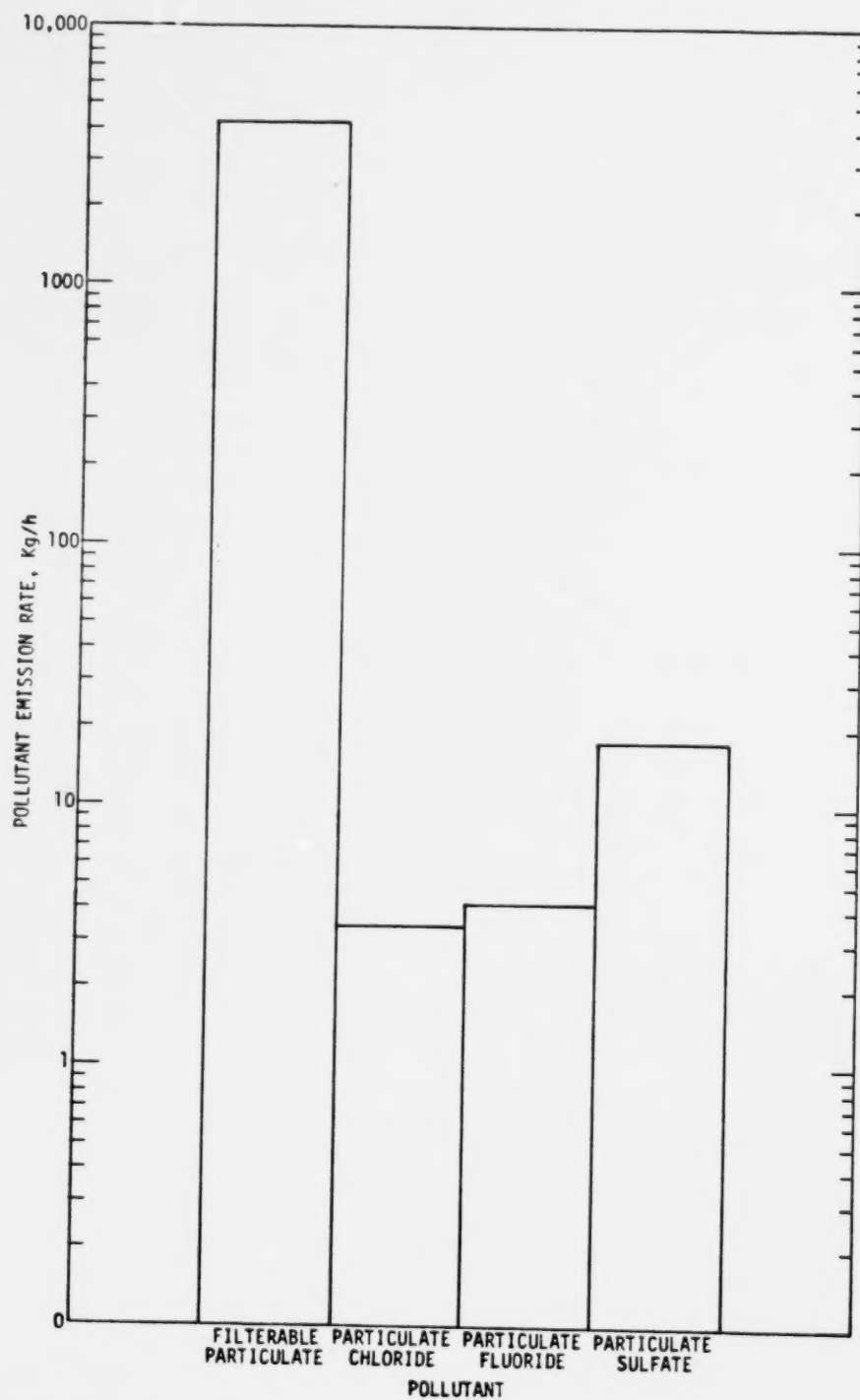


Figure 6-1. Projected particulate mass emission rates for 1983.

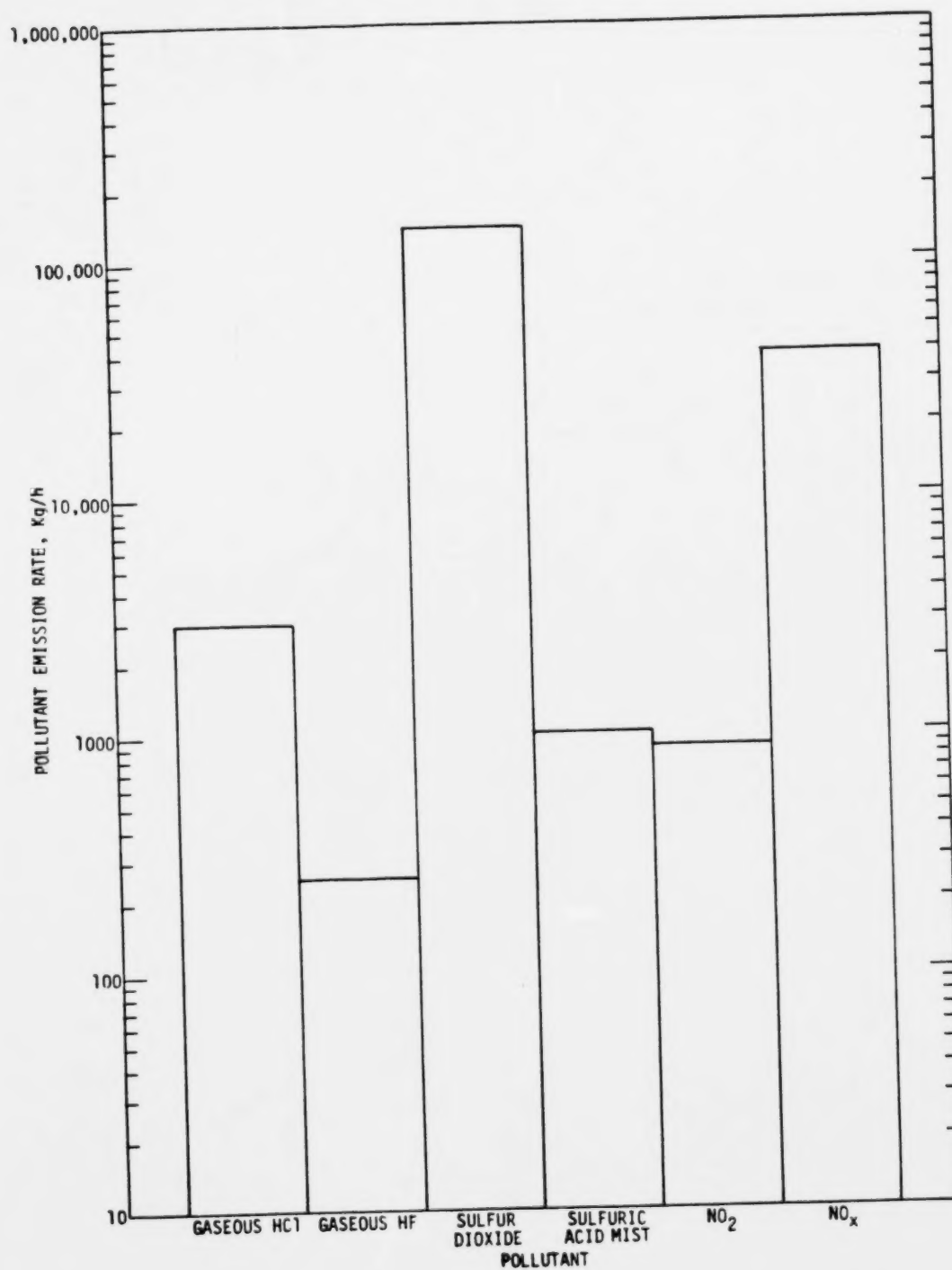


Figure 6-2. Projected gaseous mass emission rates for 1983.

APPENDIX A

OHIO RIVER POWER PLANT DATA SURVEY

Date:

A. Utility Data

1. Utility name: _____
2. Main office address: _____
3. Main office contact/position: _____
4. Phone: _____ / _____
5. Plant name: _____
6. Plant address: _____
7. Plant river mile location: _____
8. Plant contact/position: _____
9. Phone: _____ / _____

B. Meeting Participants

Name

Title

Company

C. Boiler Data

	Boiler number					
1. Service: (Base load, Standby, Floating, Peak, Other)						
2. Total hours operation (1978) ^a						
3. Average capacity factor (1978)						
4. Served by stack No.						
5. Boiler manufacturer						
6. Firing mode: (Stoker, PC, etc.)						
7. Burner configuration: (Horizontal, Opposed, Tangential, Cyclone)						
8. Year boiler placed in service						
9. Remaining life of unit, yrs						
10. Generating capacity (MW)						
Rated (nameplate)						
Maximum continuous						
Peak						
11. Heat rate Btu/kWh: Gas						
Coal						
Oil						
Current						
Fuel Mix						
12. Wet or dry bottom						
13. Fly ash reinjection (Yes or No)						
14. Stack hgt. above grade (ft.)						
15. I.D. of stack at top (inches)						
16. Excess air: Design/actual (%)						

^a Please include a chart of the normal annual load pattern for each unit.

		Boiler number					
17.	Flue gas rate (acfm)						
	@ 100% load						
	@ 75% load						
	@ 50% load						
18.	Stack gas exit temperature (°F)*						
	@ 100% load						
	@ 75% load						
	@ 50% load						
19.	Exit gas stack velocity (FPS)*						
	@ 100% load						
	@ 75% load						
	@ 50% load						
20.	Exhaust duct dimensions @ stack						
21.	Elevation to tie-in point of stack						
22.	Sample port location after control device (please attach sketch or diagram if available)						
D.	Particulate Cleaning Equipment						
	Mechanical Collectors						
	1. Manufacturer/date of installation						
	2. Type						
	3. Efficiency: Design/actual (%)*						
	Electrostatic Precipitator						
	4. Manufacturer/date of installation						
	5. Type (Weighted wire, rigid frame)						

* Identify if data are from stack test or estimate.

		Boiler number					
6. Efficiency: Design/actual (%)*							
7. Total plate area (ft ²)							
8. Flue gas temperature @ inlet ESP @ 100% load (°F)							
Other Particulate Collection Devices							
9. Type of device/date of installation							
10. Efficiency: design/actual (%)*							
E. Uncontrolled Particulate Emissions							
1. Particulate emissions*							
1b/10 ⁶ Btu							
grains/acf							
lb/hr (full load)							
tons/year (1978)							
2. Date of last stack test							
3. Applicable particulate emission regulation							
a) current requirement AQCR priority classification regulation & Section No. 1b/10 ⁶ Btu opacity, percent							
b) future requirement (date:) regulation & Section No. 1b/10 ⁶ Btu opacity, percent							
F. SO ₂ Control Equipment							
1. Type (Lime/Limestone, Double-Alkaline, etc.)							

* Identify if data are from stack test or estimate.

		Boiler number					
2.	Manufacturer						
3.	Date of installation						
4.	Efficiency: design/actual (%)*						
G. Uncontrolled SO ₂ Emissions							
1.	SO ₂ emissions*						
	1b/10 ⁶ Btu						
	ppm						
	lb/hr (full load)						
	tons/year (1978)						
2.	Date of last stack test						
3.	Applicable SO ₂ emission regulation						
	a) current requirement AQCR priority classification regulation & Section No. 1b/10 ⁶ Btu						
	b) future requirement (date:) regulation & Section No. 1b/10 ⁶ Btu						
H. NO _x Control Equipment							
1.	Type of device (staged combustion, etc.)						
2.	Manufacturer/date of installation						
3.	Efficiency: design/actual (%)*						

* Identify if data are from stack test or estimate.

		Boiler number					
I. Uncontrolled NO _x Emissions*							
1. NO _x emissions							
1b/10 ⁶ Btu							
ppm (at 3% O ₂)							
lb/hr (full load)							
tons/year (1978)							
2. Date of last stack test							
3. Applicable NO _x regulation							
a) AQCR priority classification regulation & Section No. 1b/10 ⁶ Btu							
b) future requirement (date:) regulation & Section No. 1b/10 ⁶ Btu							
J. Fuel Use							
1. Fuel consumption							
nameplate							
maximum continuous							
peak							
2. Actual fuel consumption							
coal (TPY)(1978)							
oil (barrels/yr)(1978)							
Natural gas (10 ⁶ CF/yr)(1978)							

K. Fuel Characteristics

1. Fuel types: (as received)

Heating value

% ash

% sulfur

% nitrogen

% Cl

% H₂O

Coal	Oil	Natural gas	Other

2. Location of coal source

a) seam, mine, location

b) quantity used by seam

c) planned coal source changes

3. Supplier of fuel oil

4. Natural gas supplier

5. Other fuel supplier

APPENDIX B
PLANT OPERATING DATA

TABLE B-1. PLANT A OPERATING PARAMETERS DURING TESTING PERIOD

Run number	Date (1980)	MW	Boiler eff.	Kilograms of steam per hour	Steam temp., °C	Steam pressure, kPa g	Gross heat rate, kJ/kWh	Excess air, %	Flue gas O ₂ , %	Coal usage, kg/h
M5-1	3/4	601.0	88.1	2,112,000	539	24,622	8902	1	4.23	235,000
CCS-1-1		601.1	88.1	2,111,000	540	24,643	8900	2	4.26	235,000
M5-2	3/4	575.6	88.1	2,019,000	540	24,532	8927	2	4.34	218,000
CCS-1-2		568.6	87.9	1,988,000	540	24,567	8916	3	4.53	215,000
M5-3	3/4	590.2	88.2	2,077,000	540	24,608	8960	1	4.80	224,000
CCS-2-1		590.2	88.2	2,077,000	541	24,608	8960	1	4.08	224,000
M5-4	3/5	604.1	88.0	2,146,000	539	24,622	8958	0	4.17	226,000
CCS-2-2		604.1	88.0	2,146,000	539	24,622	8958	0	4.17	226,000
M5-5	3/6	461.3	87.8	1,150,000	541	24,677	9081	4	5.55	172,000
CCS-3-1		478.5	87.9	1,212,000	540	24,691	9056	3	5.23	180,000
M5-6	3/7	602.0	88.3	2,121,000	540	24,608	8939	0	3.97	232,000
CCS-4-1		602.3	88.3	2,123,000	539	24,608	8941	0	3.94	234,000
M5-7	3/7	597.0	88.2	2,102,000	541	24,636	8933	0	4.16	225,000
CCS-4-2		600.0	88.3	2,116,000	540	24,636	8928	0	4.07	226,000
M5-8	3/10	600.4	87.9	2,110,000	540	24,608	8875	3	4.47	229,000
CCS-5-1		600.9	88.0	2,110,000	541	24,574	8871	3	4.47	228,000
M5-9	3/10	601.5	88.1	2,123,000	539	24,546	8915	2	4.26	228,000
CCS-5-2		601.5	88.0	2,124,000	539	24,567	8907	3	4.31	227,000
M5-10	3/11	598.1	88.6	2,131,000	540	24,677	9076	1	3.50	229,000
CCS-6-1		598.3	88.6	2,127,000	540	24,677	9073	1	3.53	229,000
M5-11	3/11	598.1	88.4	2,108,000	540	24,677	8961	2	3.99	231,000
CCS-6-2		598.1	88.4	2,108,000	540	24,677	8961	2	3.99	231,000

TABLE B-2. PLANT B OPERATING PARAMETERS DURING TESTING PERIOD

Run number	Date (1980) and time	MW	Percent of rated capacity	Kilograms of steam per hour	Daily steam temperature (superheater outlet), °C	Oxygen, ^a %
M5-1	4/7 1434 to 1748	85	68	248,000	535	3.2
M5-2	4/8 1242 to 1643	135	108	408,000	538	4.8
M5-3	4/9 945 to 1254	106	85	321,000	532	4.9
M5-4	4/9 1356 to 1715	97	78	273,000	530	5.2
M5-5	4/10 858 to 1145	101	81	293,000	535	4.8
M5-6	4/10 1324 to 1546	95	76	260,000	535	4.2
M5-7	4/11 904 to 1128	114	91	329,000	535	2.9
M5-8	4/11 1200 to 1434	102	82	311,000	535	3.5
M5-9	4/14 916 to 1145	109	87	318,000	533	5.2
M5-10	4/14 1300 to 1718	89	71	251,000	533	5.0
M5-11	4/15 945 to 1121	88	70	261,000	533	4.7
M5-12	4/15 1345 to 1606	95	76	265,000	533	5.4

^a Plant data obtained at economizer inlet.

TABLE B-3. PLANT C OPERATING PARAMETERS DURING TESTING PERIOD

Run number	Date (1980) and time	MW	Percent of rated capacity	Kilograms of steam per hour	Daily steam temperature (superheater outlet), °C
M5-1	4/17 1045 to 1420	142	87	462,700	549
M5-2	4/17 1519 to 1755	130	80	382,400	549
M5-3	4/18 929 to 1211	150	92	464,000	552
M5-4	4/18 1340 to 1613	145	89	501,700	552
M5-5	4/21 938 to 1205	153	94	506,200	549
M5-6	4/21 1346 to 1618	147	90	476,700	549
M5-7	4/22 927 to 1208	159	98	536,200	549
M5-8	4/22 1342 to 1604	162	99	525,700	547
M5-9	4/23 854 to 1126	157	96	517,100	- ^a
M5-10	4/23 1225 to 1443	156	96	514,800	- ^a

^a Plant did not record data on this date.

TABLE B-4. PLANT D OPERATING PARAMETERS DURING TESTING PERIOD

Run no.	Date (t.me)	Load (MW)	Main steam pressure kPa g	Main steam temperature °C	Reheat steam pressure kPa g	Reheat steam temperature °C	Air flow Gg/h	Flue gas oxygen (%)	Coal consumption Mg/h	Net unit heat rate kJ/MJ	Boiler efficiency (%)	Main steam	Heat added GJ/h Reheat steam	WCAH
MS-1	8/5/80 1240-1521	346	17,389	577	2751	535	1162	5.0	130.7	2890	88.9	2434	485	25.0
CCS1-1	8/5/80 1245-1405	339	17,348	579	2655	533	1146	5.1	127.2	2880	88.9	2351	467	24.7
MS-2	8/5/80 1625-1821	333	17,313	576	2951	536	1124	4.9	150.5	2939	89.0	2924	561	25.5
CCS1-2	8/5/80 1600-1700	380	17,568	579	3144	541	1255	4.6	145.0	2945	88.8	2788	556	25.8
MS-3	8/6/80 0945-1136	281	17,058	580	2172	536	1013	6.0	100.0	2876	88.9	1771	359	24.3
CCS2-1	8/6/80 1045-1145	336	17,340	584	2503	538	1141	5.3	122.1	2916	88.9	2240	452	24.4
MS-4	8/6/80 1300-1509	399	17,686	590	3303	536	1287	4.6	152.8	2946	88.9	2974	567	26.3
CCS2-2	8/6/80 1245-1350	392	17,644	543	3254	535	1293	4.7	151.4	2950	88.9	2940	557	26.3
MS-5	8/17/80 0722-0907	177	16,762	584	1420	539	927	9.5	74.7	3071	88.3	1275	272	26.9
CCS3-1	8/7/80 0815-0915	176	16,762	387	1427	540	928	9.6	74.9	3094	88.3	1283	275	27.5
MS-6	8/7/80 1027-1224	361	17,472	594	2724	540	1247	5.4	133.9	2936	88.9	2427	493	25.6
CCS3-2	8/7/80 1015-1115	320	17,148	613	2282	540	1178	6.3	114.9	2961	88.8	2035	420	25.2
MS-7	8/8/80 0803-0955	372	17,486	572	2834	529	1273	5.1	140.4	2856	88.9	2459	475	24.7
CCS4-1	8/8/80 0905-1005	392	17,610	573	3110	535	1332	4.8	151.6	2832	88.9	2695	515	25.5
MS-8	8/8/80 1100-1259	393	17,596	570	3310	540	1352	4.6	158.3	2948	89.0	2976	573	25.7

(continued)

TABLE B-4 (continued)

Run no.	Date (time)	Load (MW)	Main steam pressure kPa g	Main steam temperature °C	Reheat steam pressure kPa g	Reheat steam temperature °C	Air flow Gg/h	Flue gas oxygen (%)	Coal consumption Mg/h	Net unit heat rate kJ/MJ	Boiler efficiency (%)	Main steam	Heat added GJ/h Reheat steam	UCAH
CCS-2	8/8/80 1050-1150	394	17,582	569	3310	540	1351	4.6	158.1	2947	89.0	2972	573	25.7
MS-9	8/12/80 0940-1151	332	17,224	571	2682	538	1224	5.5	136.2	2881	88.9	2354	481	24.9
CCS-1	8/12/80 0950-1050	332	17,251	572	2682	538	1214	5.5	137.5	2880	88.9	2347	479	25.0
MS-10	8/12/80 1235-1432	339	17,279	574	2730	539	1171	5.3	135.6	2908	89.0	2429	496	24.5
CCS-2	8/12/80 1205-1305	334	17,210	572	2689	538	1188	5.4	133.8	2903	88.9	2386	487	24.6

TABLE B-5. PLANT E OPERATING PARAMETER DURING TESTING PERIOD

Run no.	Date (time)	Load (MW)	Main steam pressure kPa g	Final flue gas temperature, °C		Reheat pressure kPa g	Reheat temperature °C	Main steam temperature °C
				A	B			
M5-1	8/18/80 1330-1526	169	12,620	181	178	2990	534	535
CCS1-1	8/18/80 1250-1350	170	12,760	179	178	3020	534	533
M5-2	8/18/80 1615-1816	169	12,500	182	178	2965	535	535
CCS1-2	8/18/80 1555-1655	169	12,480	182	180	2965	537	534
M5-3	8/19/80 1030-1226	160	12,580	178	176	2890	520	527
CCS2-1	8/19/80 1105-1205	158	12,580	180	177	2985	522	524
M5-4	8/19/80 1438-1636	175	12,580	180	179	3140	529	532
CCS2-2	8/19/80 1310-1410	174	12,580	182	180	3170	527	529
M5-5	8/20/80 0930-1159	146	12,430	170	171	2620	519	532
CCS3-1	8/20/80 1040-1140	150	12,410	174	174	2620	520	533

(continued)

TABLE B-5 (continued)

Run no.	Date (time)	Load (MW)	Main steam pressure kPa g	Final flue gas temperature, °C		Reheat pressure kPa	Reheat temperature °C	Main steam temperature °C
				A	B			
M5-6	8/20/80 1300-1504	175	12,580	176	177	3100	526	531
CCS3-2	8/20/80 1250-1350	175	12,500	176	176	3100	527	533
M5-7	8/21/80 900-1104	167	12,700	178	173	3120	537	534
CCS4-1	8/21/80 1030-1130	175	12,630	183	174	3310	541	537
M5-8	8/21/80 1138-1344	175	12,570	180	171	3310	536	535
CCS4-2	8/21/80 1215-1315	175	12,410	176	167	3310	538	535
M5-9	8/22/80 0930-1124	144	12,580	171	167	2520	522	534
CCS5-1	8/22/80 1030-1130	151	12,530	173	168	2670	526	536
M5-10	8/22/80 1154-1418	175	12,460	177	172	3170	532	538
CCS5-2	8/22/80 1245-1345	175	12,480	180	172	3170	535	538
CCSI5-1	8/22/80 1055-1155	158	12,500	175	170	2790	527	536
CCSI5-2	8/22/80 1315-1415	175	12,480	180	172	3170	535	538

APPENDIX C
SAMPLING LOCATIONS

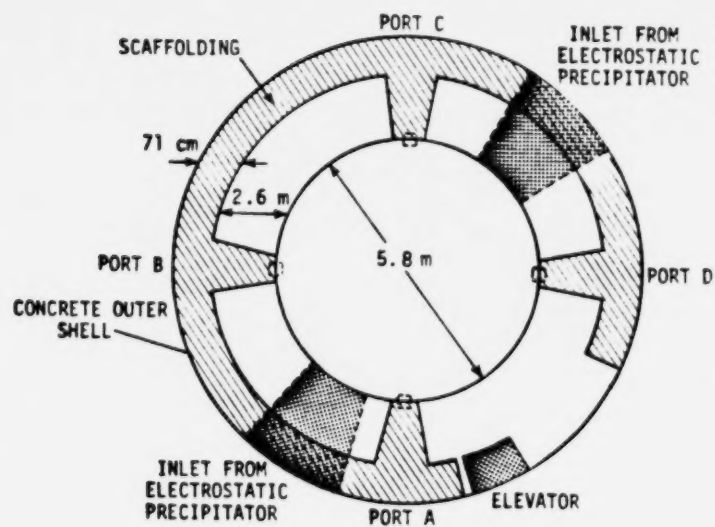
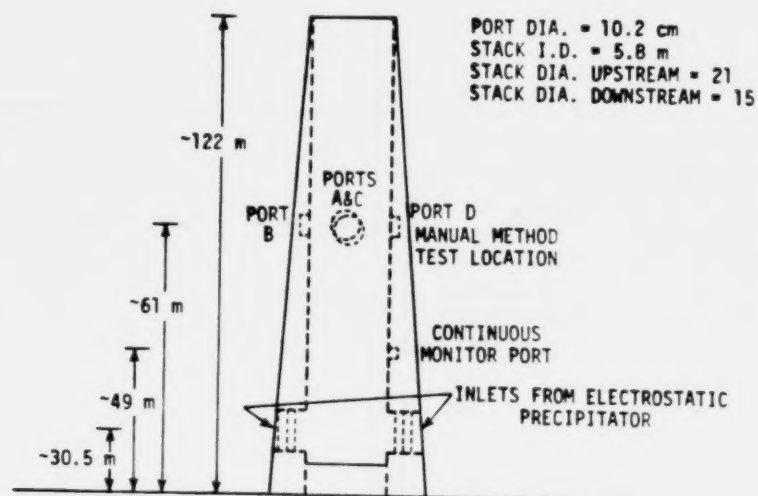


Figure C-1. Plant A sampling location.

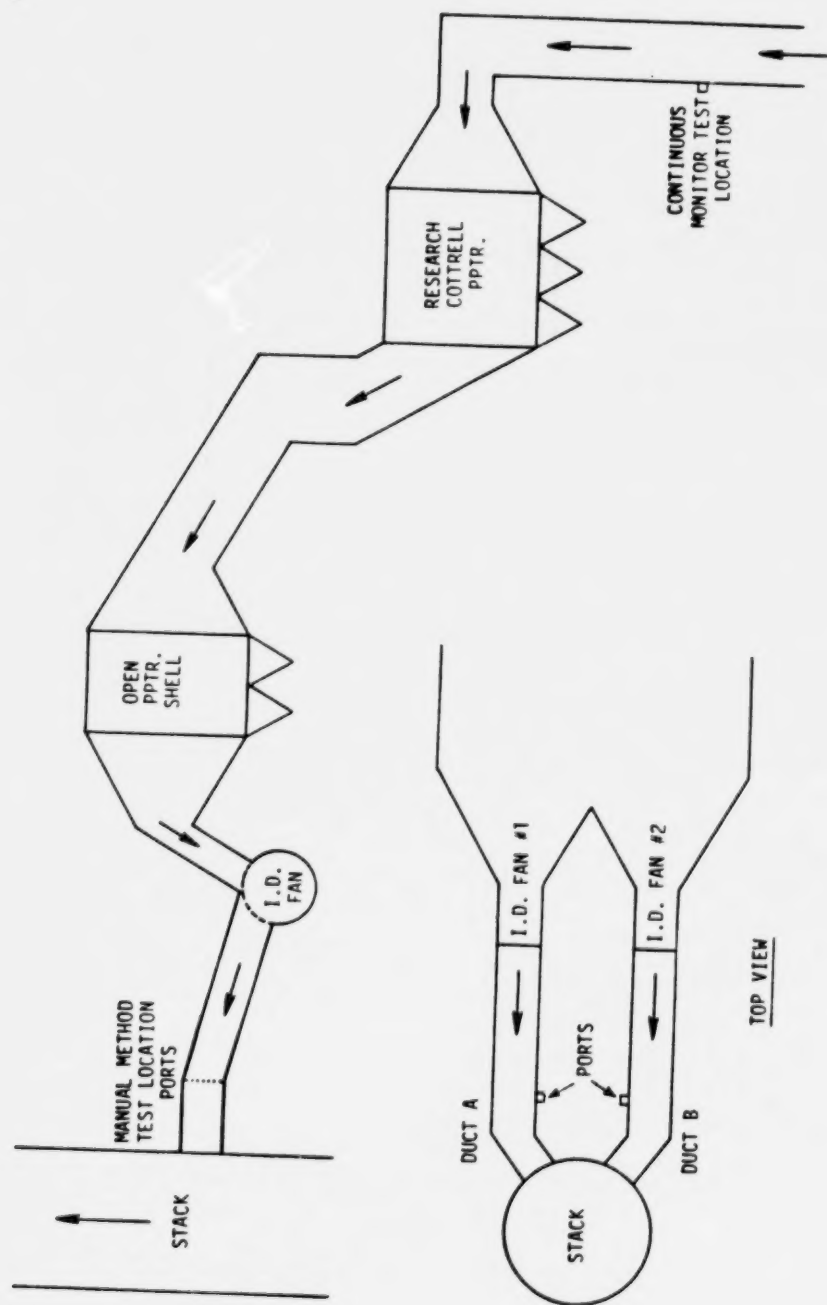


Figure C-2. Plant B flue gas flow diagram and sampling locations.

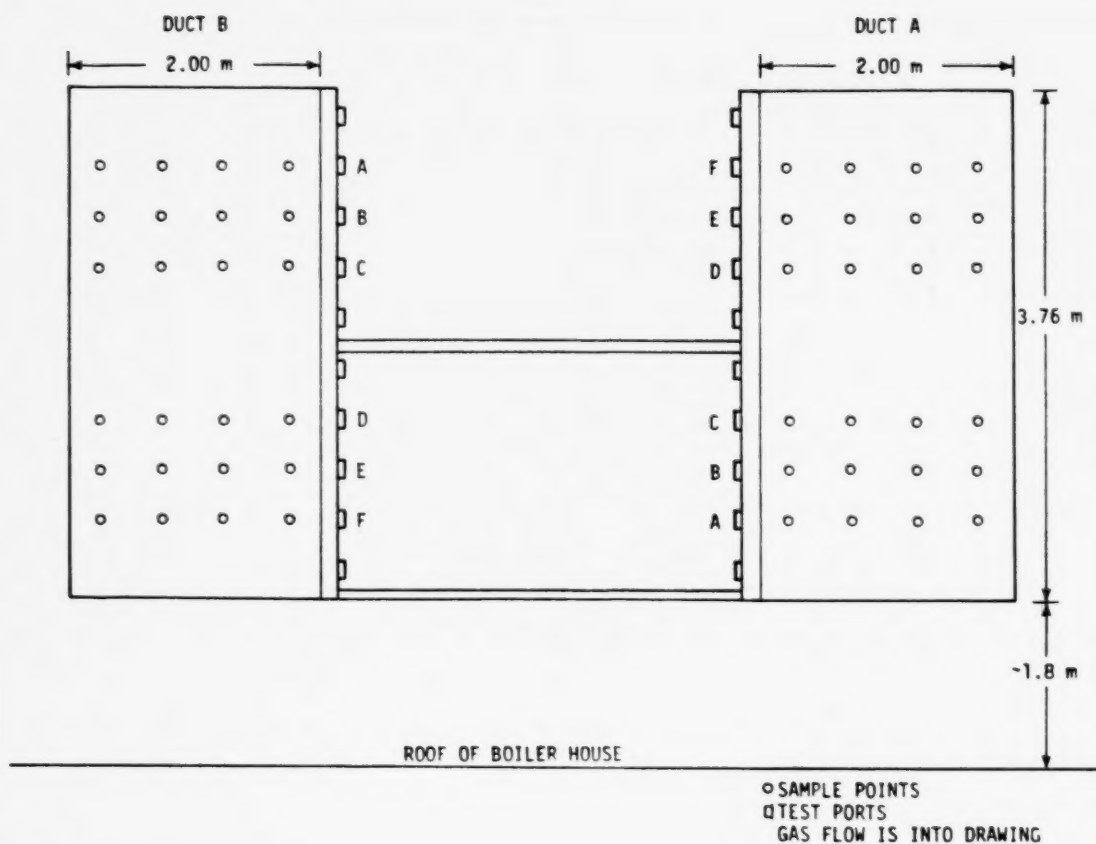
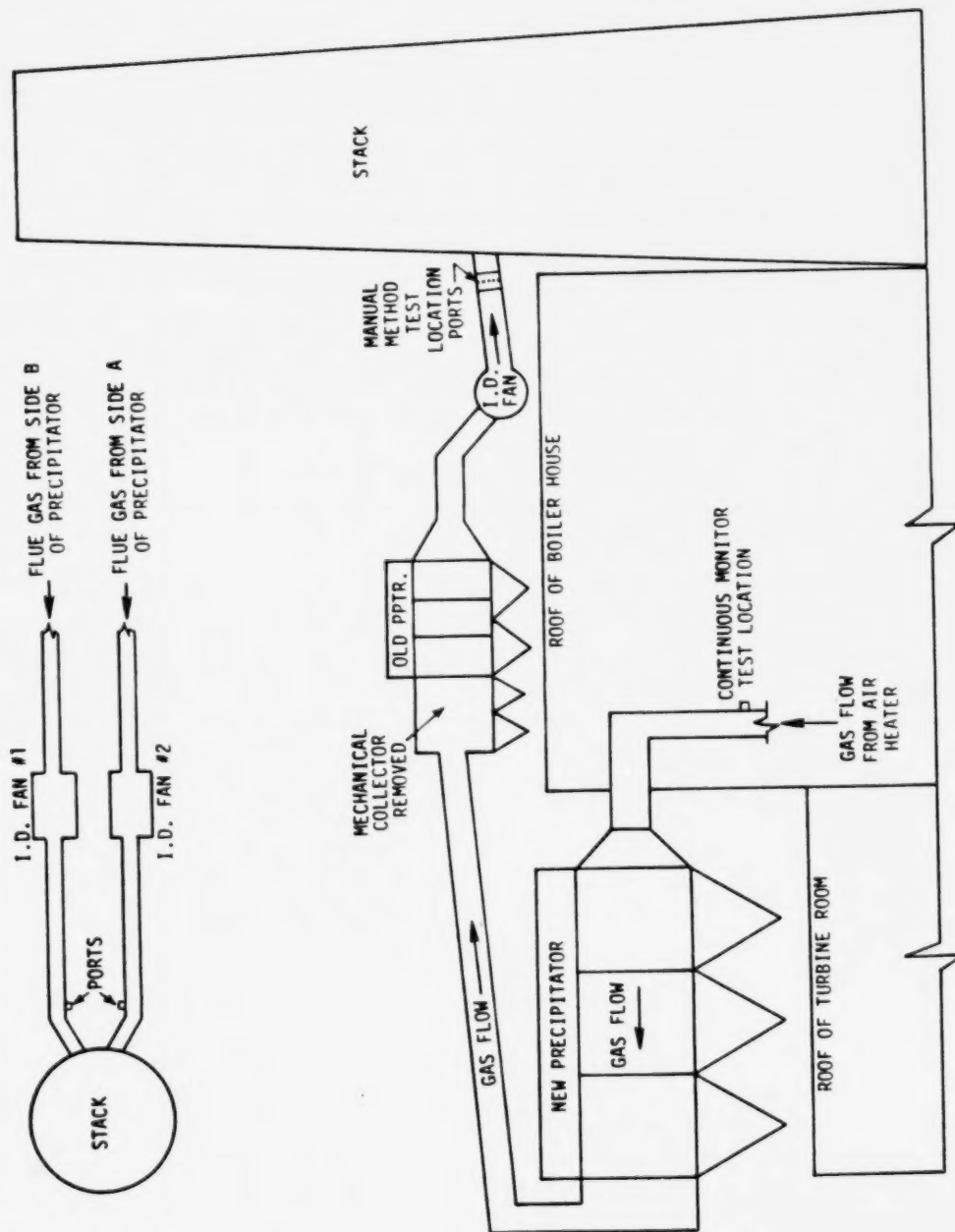


Figure C-3. Cross section of sampling location at Plant B.



C-5

Figure C-4. Plant C flue gas flow diagram and sampling locations.

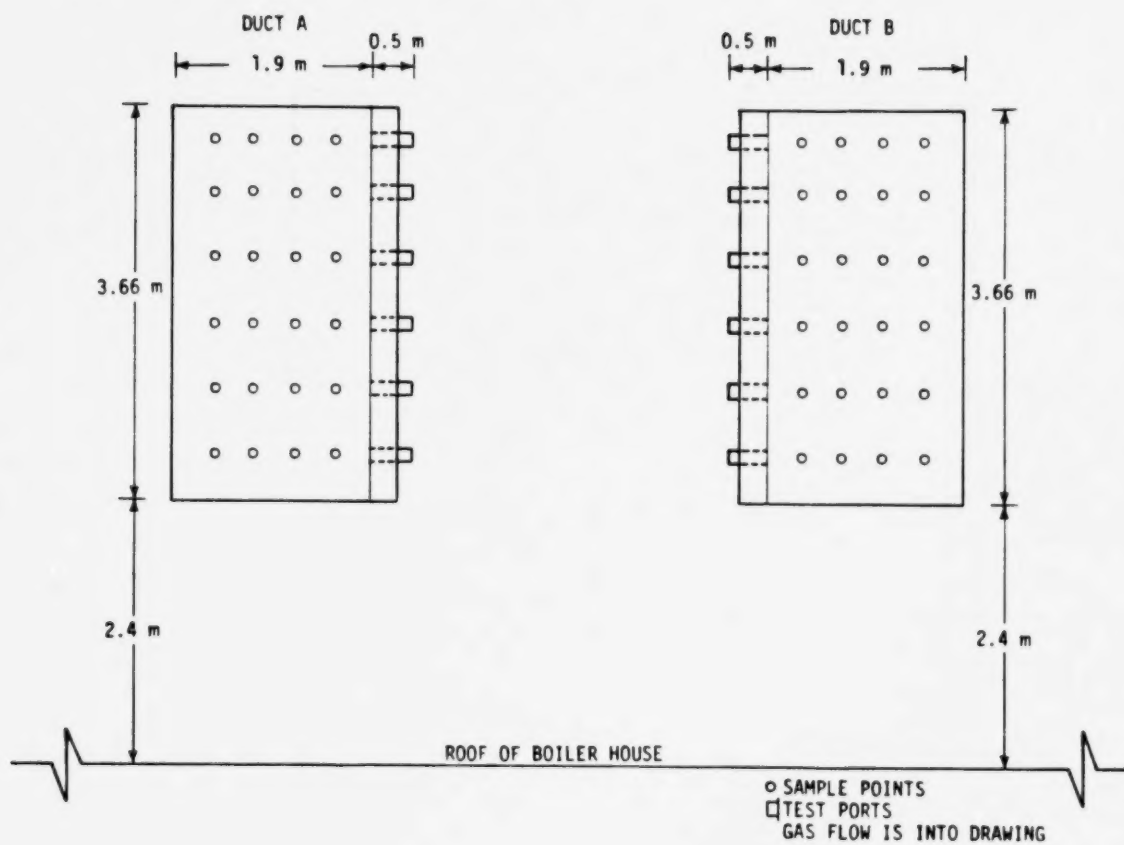


Figure C-5. Cross section of sampling location at Plant C.

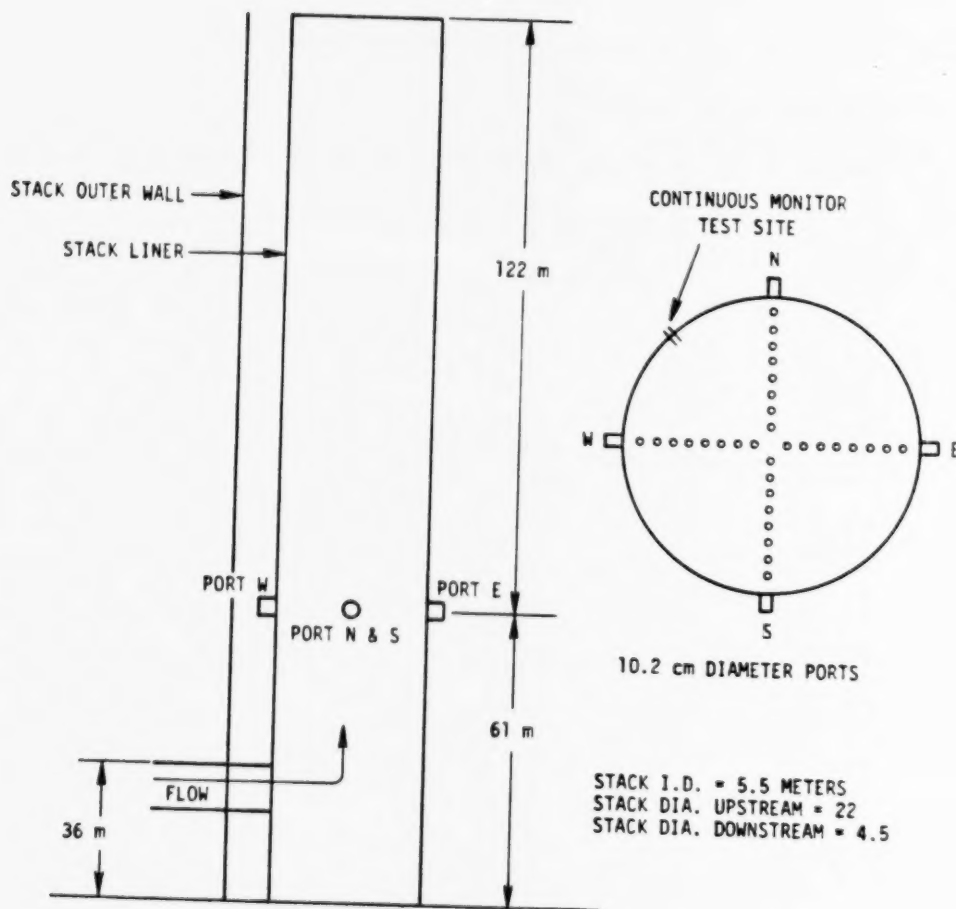


Figure C-6. Plant D sampling location.

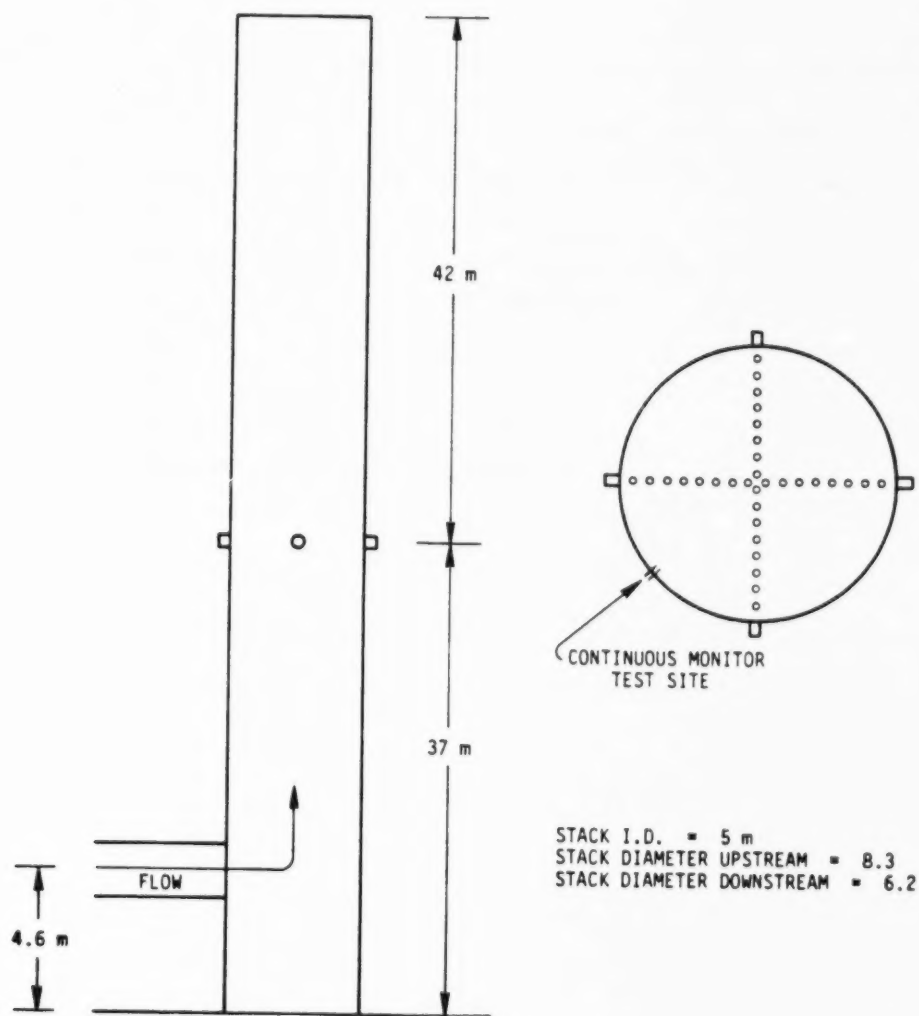


Figure C-7. Plant E sampling location.

APPENDIX D
SAMPLING AND ANALYTICAL PROCEDURES

DETERMINATION OF PARTICULATE EMISSIONS

The following method was used in this test program. Sampling procedures followed those described in Method 5 of the Federal Register.*

SAMPLING APPARATUS

The particulate sampling train used in these tests at the exit stack met design specifications established by the Federal EPA and was assembled by PEDCo personnel. It consisted of:

Nozzle - Stainless steel (316) with sharp, tapered leading edge and accurately measured round opening.

Probe - Borosilicate glass with a heating system capable of maintaining a minimum gas temperature of 120°C at the exit end during sampling.

Pitot Tube - Type S pitot tube that met all geometry standards was attached to probe to monitor stack gas velocity.

Filter Holder - Pyrex glass with heating system capable of maintaining a filter temperature of approximately 120°C.

Draft Gauge - An inclined manometer made by Dwyer with a readability of 0.25 mm H₂O in the 0-25.4 mm range was used.

Impingers - Four impingers connected in series with glass ball joints. The first, third, and fourth impingers were of the Greenburg-Smith design, modified by replacing the tip with a 1.3 cm I.D. glass tube extending to 1.3 cm from the bottom of the flask.

* Federal Register, Vol. 42, No. 160, August 18, 1977.

Metering System - Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 3°C, dry gas meter with 2 percent accuracy, and related equipment, to maintain an isokinetic sampling rate and to determine sample volume. The dry gas meter is made by Rockwell and the fiber vane pump is made by Gast.

Barometer - Bourden tube type to measure atmospheric pressures to +2.5 mm Hg.

SAMPLING PROCEDURE

After selecting the sampling site and the minimum number of traverse points, the stack pressure, temperature, moisture, and range of velocity head were measured according to procedures described in the Federal Register.*

Approximately 200 grams of silica gel were weighed and placed in a sealed impinger prior to each test. Glass fiber filters** (87 mm diameter) were desiccated for at least 24 hours and weighed to the nearest 0.1 mg on an analytical balance. One hundred ml of distilled water were placed in each of the first two impingers; the third impinger was initially empty; and the impinger containing the silica gel was placed next in series. The train was set up with the probe as shown in Figure D-1. The sampling train was leak checked at the sampling site prior to each test run by plugging the inlet to the nozzle and pulling a 380 mm Hg vacuum, and at the conclusion of the test by plugging the inlet to the nozzle and pulling a vacuum equal to the highest vacuum reached during the test run.

* Federal Register, Vol. 42, No. 160, August 18, 1977.

** Gelman Type A.

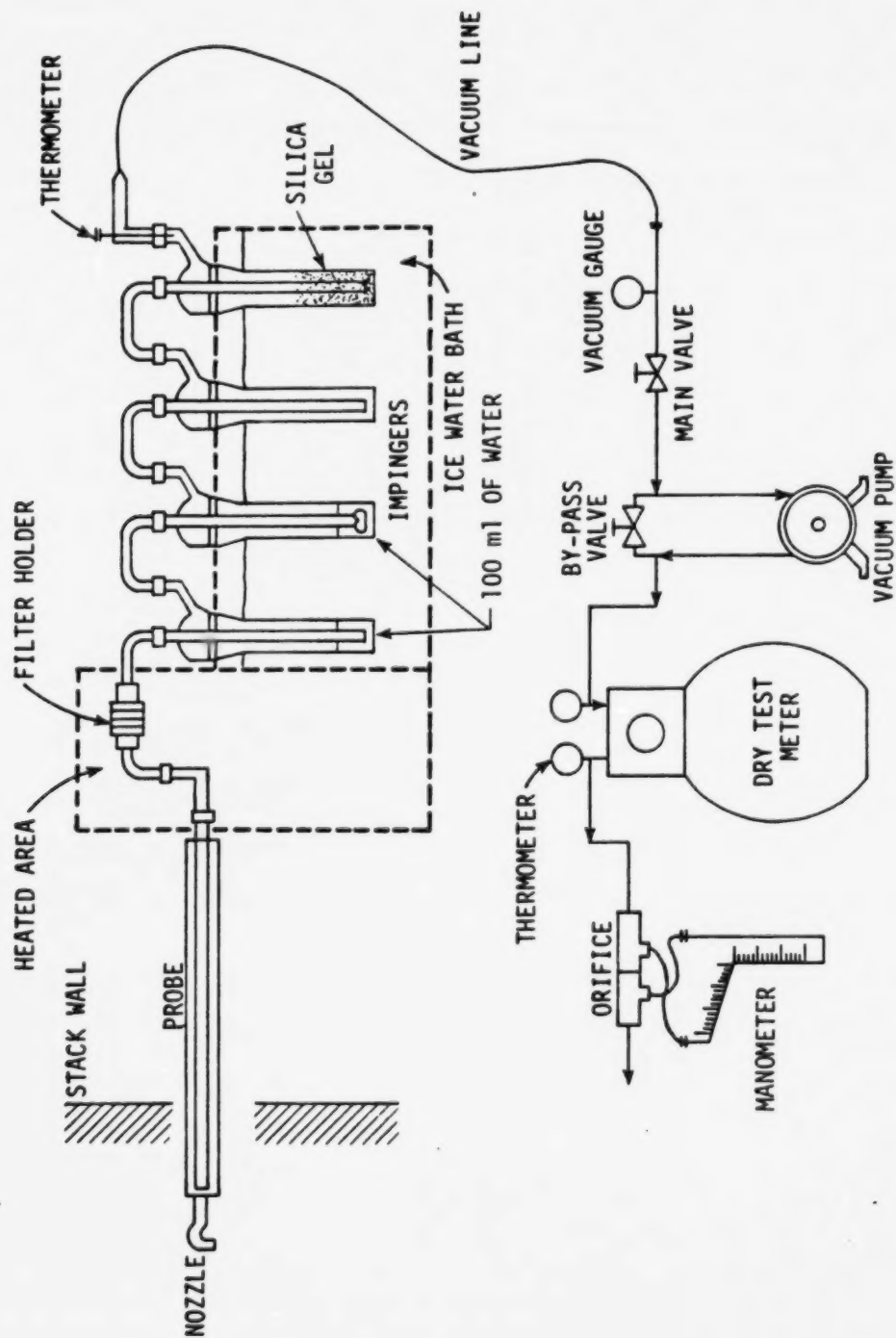


Figure D-1. Method 5 sampling train.

The pitot tube and lines were leak checked at the test site prior to each test run and at the conclusion of each test run. The check was made by blowing into the impact opening of the pitot tube until 7.6 or more cm of water were recorded on the manometer and then capping the impact opening and holding it for 15 seconds to assure it was leak free. The static pressure side of the pitot tube was leak checked using the same procedure, except suction was used to obtain the 7.6 cm H₂O manometer reading. Crushed ice was placed around the impingers to keep the temperature of the gases leaving the last impinger at 20°C or less.

During sampling, stack gas and sampling train data were recorded at each sampling point and when significant changes in stack flow conditions occurred. Isokinetic sampling rates were set throughout the sampling period with the aid of a nomograph or calculator. All sampling data were recorded on the Particulate Field Data Sheet.

SAMPLE RECOVERY PROCEDURE

The sampling train was moved carefully from the test site to the cleanup area. The volume of water from the first three impingers was measured. Sample fractions were recovered as follows:

Container No. 1 - The filter was removed from its holder and placed in a petri dish and sealed.

Container No. 2 - Loose particulate and acetone washings from all sample-exposed surfaces prior to the filter were placed in a polyethylene container, sealed, and labeled. Particulate was removed from the probe with the aid of a

brush and acetone rinsing. The liquid level was marked after the container was sealed.

Container No. 3 - A minimum of 200 ml of acetone was taken for the blank analysis. The blank was obtained and treated in a similar manner as the acetone washing.

Container No. 4 - Distilled water in the impinger section of the sampling train was placed in a polyethylene container. The impingers and connecting glassware were rinsed with distilled H₂O and this rinse was added to the container for shipment to the laboratory.

Container No. 5 - A minimum of 200 ml of distilled water was taken for the blank analysis. The blank was obtained and treated in a similar manner as the water rinse.

The silica gel from the fourth impinger was weighed and recorded on the Sample Recovery and Integrity Data Sheet with other pertinent data.

ANALYTICAL PROCEDURES

The following procedures were used and follow the methods described in the Federal Register.*

Container No. 1 - The filter and any loose particulate matter from this sample container were placed into a tared glass weighing dish, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

Container No. 2 - The acetone washings were transferred to a tared beaker and evaporated to dryness at ambient temperature and pressure, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg.

Container No. 3 - The acetone blank was transferred to a tared beaker and evaporated to dryness at ambient temperature and pressure. The blank was then desiccated for 24 hours to a constant weight and weighed to the nearest 0.1 mg.

Container No. 4 and 5 - The contents of these containers were stored for future analysis.

* Federal Register, Vol. 42, No. 160, August 18, 1977.

The term "constant weight" means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater between two consecutive readings, with no less than 6 hours of desiccation between weighings. All analytical data are recorded on the Analytical Particulate Data Sheet. Acetone blank data are recorded on the Acetone Blank Data Sheet.

CONTROLLED CONDENSATION SYSTEM (CCS) SAMPLING PROCEDURE

The Controlled Condensation System (CCS) was utilized to simultaneously collect and differentiate particulate sulfate, chloride, fluoride, SO_3 (as H_2SO_4), and SO_2 ; and to obtain samples suitable for HCl and HF determinations. The CCS consists of a heated Vycor probe, a heated quartz filter which collects the particulate matter, a modified Graham condenser which cools the gas below the acid dew point to collect the SO_3 (H_2SO_4 vapor), and impingers which scrub the SO_2 , HCl, and HF from the flue gas being sampled. The expected distribution of the species collected in the CCS is shown in Table D-1.

SAMPLING APPARATUS

The source sampling train used in these tests met design specifications established by the Federal EPA and was assembled by PEDCo personnel. It consisted of:

Probe - Vycor quartz with a heating system capable of maintaining a minimum gas temperature of 315°C at the exit end during sampling.

Filter Holder - Quartz with a heating system capable of maintaining a filter temperature of approximately 290°C .

Control Condensation Coil - Modified Graham condenser with an enclosed 60 mm medium frit.

Recirculating Bath - Capable of measuring the temperature and maintaining 60°C water recirculating through the Graham condenser.

TABLE D-1. EXPECTED DISTRIBUTION OF PARTICULATE AND
GASEOUS SULFUR SPECIES IN CCS

Sample Train Component	Collected Species
Probe	Chloride, Fluoride, and Sulfate Particulate
Filter	Chloride, Fluoride, and Sulfate Particulate
Controlled Condensation Coil	H_2SO_4
6% H_2O_2	SO_2
6% H_2O_2	SO_2
8% Na_2CO_3 Impinger	HCl, HF
Silica Gel, 200 g	H_2O (Moisture)

Impingers - Four impingers connected in series with glass ball joints. The first, second, and third were of the Greenburg-Smith design. The fourth was a Greenburg-Smith design modified by replacing the tip with a 1.3 cm I.D. glass tube extending to 1.3 cm from the bottom of the flask.

Temperature Monitor - RDF digital temperature indicator, series-2000 with iron/constantan sensors or equivalent.

Metering System - Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 2°C dry gas meter with 2 percent accuracy, and related equipment, to determine sample volume. The dry gas meter is made by Rockwell and the fiber vane pump is made by Gast.

Filter - 37 mm tissue quartz filters.

SAMPLING PROCEDURE

Preparation of the sampling train was performed in the designated clean-up area. The quartz filter* (37 mm diameter) was placed in the filter holder, 100 ml of 6 percent H_2O_2 was placed into each of the first two impingers, 100 ml of 3 percent Na_2CO_3 into the third, and the fourth impinger contained 200 grams of silica gel. With the probe still out of the stack, the train was assembled at the sampling site as shown in Figure D-2.

The sampling train was leak-checked at the sampling site prior to each test run by plugging the inlet to the nozzle and pulling a 380 mm Hg vacuum. Once the desired vacuum was reached, the flowrate was measured with the flowmeter for 1 minute. If the leak rate was less than 0.3 lpm the system was used to obtain the sample. Leaks were corrected prior to any testing. Following the leak test, the probe and filter holder were heated.

* Pallflex Tissuquartz.

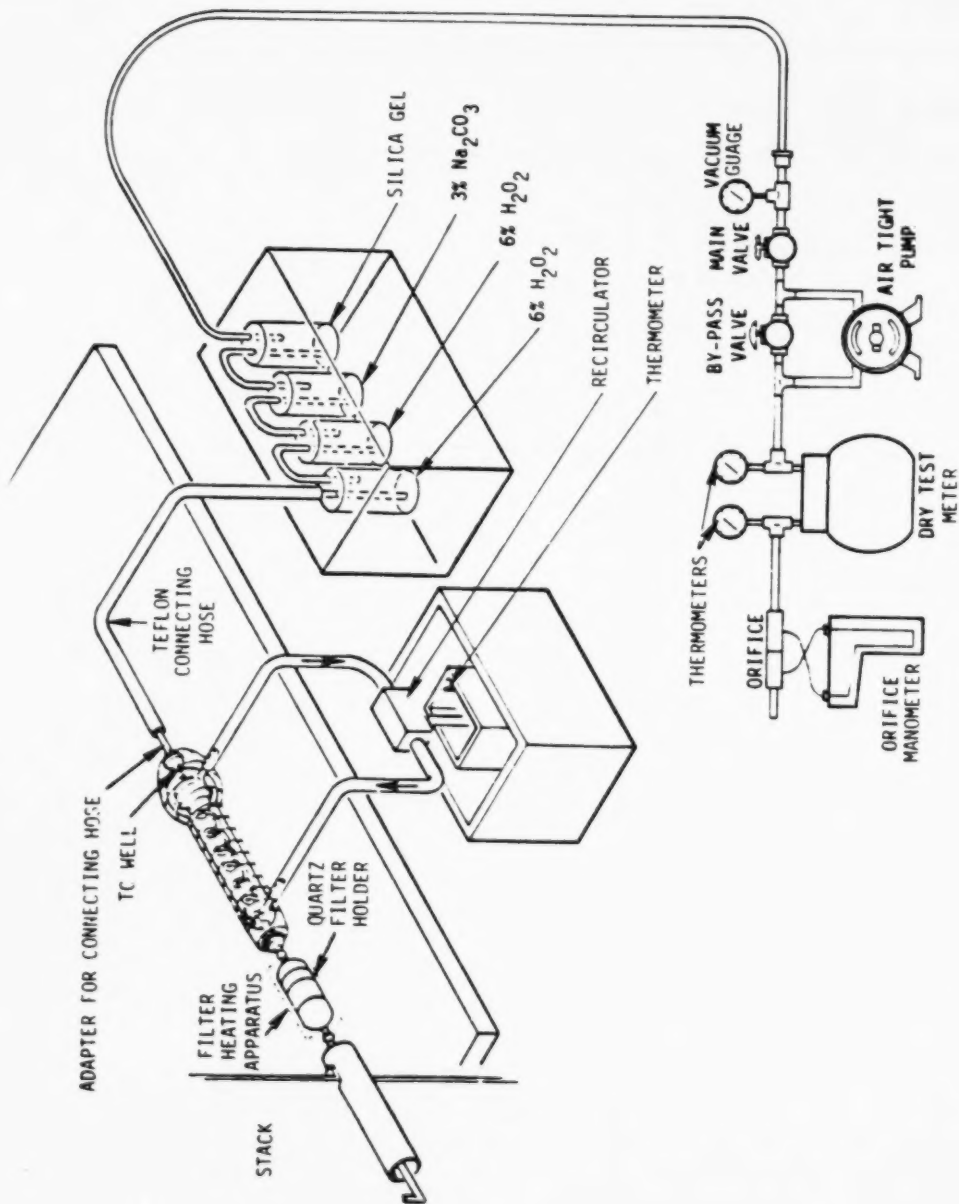


Figure D-2. Control condensation sampling train.

A flow rate of 10 lpm was maintained throughout the test. Once the probe and filter holder reached their desired temperatures of 315°C and 290°C, the run was commenced. The probe was positional approximately 1 m from the stack wall. The sample was taken for one hour, or until 1/2 to 2/3 of the length of the coil was frosted with H₂SO₄. All sampling data was recorded on the controlled condensate field data sheet.

At the end of the sampling period, the probe was removed from the duct, and the pump slowly shut off. The sampling train was not leak checked at the conclusion of the test run since this could result in the acid mist being pulled into the first impinger.

SAMPLE RECOVERY PROCEDURE

The sampling train was moved carefully from the test site to the clean up area. A sample of the reagents used in the sample preparation and recovery was taken for use as a blank. Sample fractions were recovered as follows:

Container No. 1 - The probe was rinsed with 30 to 50 ml of acetone and placed in a sealed, labeled container.

Container No. 2 - The filter was removed from its holder along with any loose particulate and placed in a sealed, labeled container.

Container No. 3 - The controlled condensate coil was rinsed with 30 ml (in 10 ml increments) of distilled deionized water, and put into a container. This container was then sealed and labeled..

Container No. 4 - Contents of the first and second impingers were combined, measured, and placed in a container. These impingers and connecting glassware were rinsed with distilled, deionized water and was placed in the same container which was then sealed and labeled.

Container No. 5 - Contents of the third impinger were transferred to a container. This impinger and connecting glassware were rinsed with 8 percent Na_2CO_3 and the rinse was placed in the same container which was then sealed and labeled.

Silica gel contained in the fourth impinger was weighed and then discarded. All sample recovery data was recorded on the CCS Sample Recovery and Integrity Data Sheet.

ANALYTICAL PROCEDURE

The analytical procedure followed is illustrated in Figure D-3.

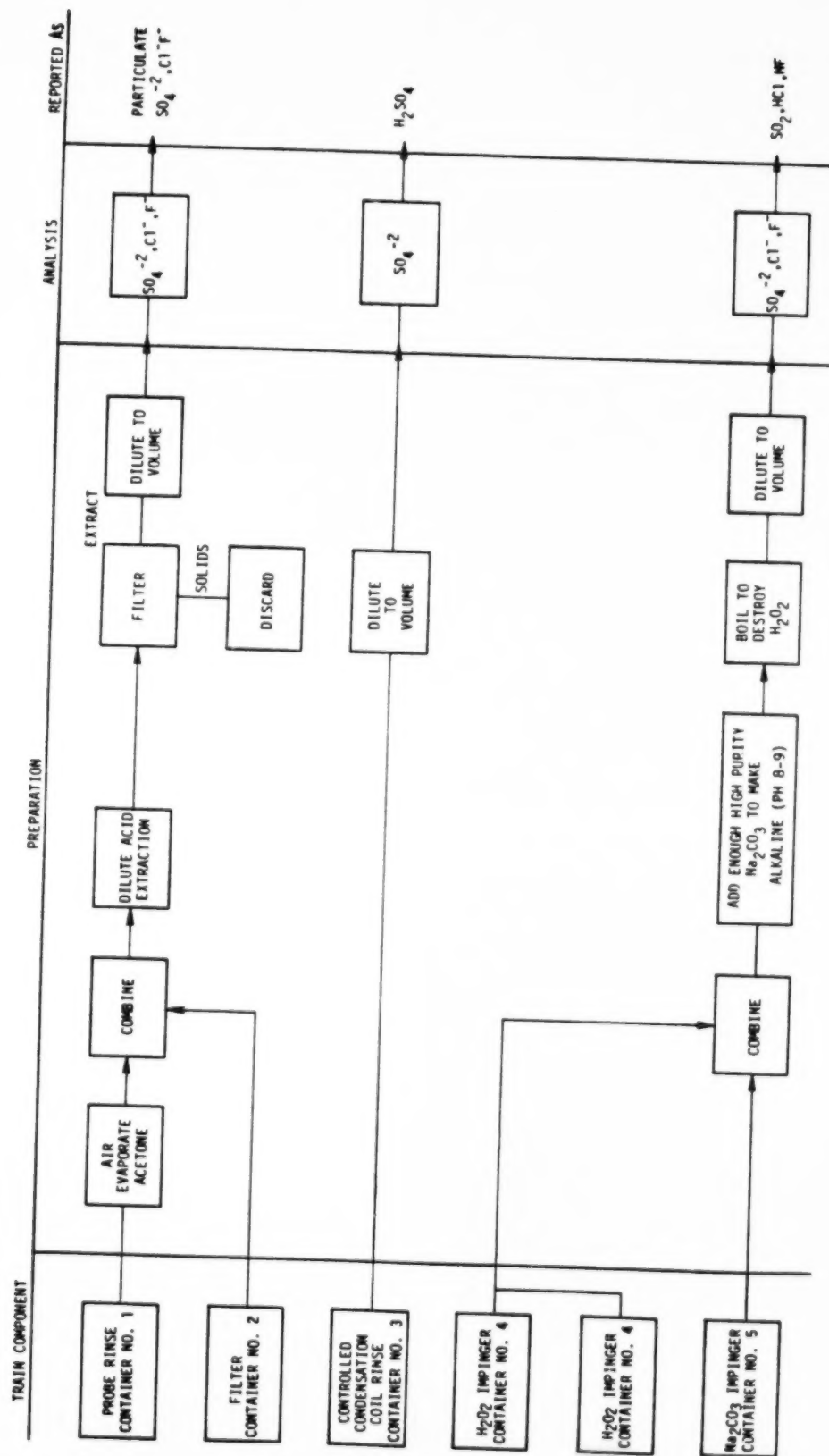


Figure D-3 . CCS sample analysis procedure.

PARTICLE SIZE DISTRIBUTION SAMPLING PROCEDURE
USING THE ANDERSEN MARK III IMPACTOR

The Andersen stack samplers are in-stack, multistage, cascade impactors which measures the size distribution of particulate emissions and was used to obtain the particle size distribution samples.

SAMPLING APPARATUS

The source sampling train used in these tests met design specifications established by the Federal EPA and was assembled by PEDCo personnel. It consisted of:

Nozzle - Stainless steel (316) with sharp tapered leading edge and accurately measured round opening.

Pitot Tube - Type S pitot tube that meets all geometry standards and is attached to probe to monitor stack gas velocity.

Draft Gauge - An inclined manometer made by Dwyer with a readability of 0.25 mm H₂O in the 0 to 25.4 mm range was used.

Metering System - Vacuum gauge, leak-free pump, thermometers capable of measuring temperature to within 2°C, dry gas meter with 2 percent accuracy, and related equipment, to maintain an isokinetic sampling rate and to determine sample volume. The dry gas meter is made by Rockwell and the fiber vane pump is made by Gast.

Temperature Monitor - RDF digital temperature indicator, Series-2000 with iron/constantan sensors or equivalent.

Condenser - Capable of maintaining a temperature of 20°C, with an attached thermometer to monitor temperature.

Impactor - The Andersen Mark III with eight stages plus the backup filter was used. This impactor uses 63.5 mm diameter filters.

COLLECTION SUBSTRATES

For the different stages of the impactor Reeve Angel 934 AH glass fiber filters were used as the collection substrates. Tests using these substrates were used to determine size distributions and not for elemental analysis.

Prior to using the Reeve Angel filters they were baked at approximately 200°C for 1 to 2 hours. After removal from the oven, the substrate was conditioned in a desiccator for 12 to 24 hours prior to weighing. A Perkin-Elmer AD-2 electron balance with 0.01 mg sensitivity was used to weigh the filters. Final weights were determined using the same balance.

For the elemental analysis tests, Zefluor filters were used as the collection substrate. This smooth Teflon organic membrane can withstand temperatures of 150°C, is not affected by SO₂, and can be used for x-ray fluorescence (XRF) non-destructive elemental analysis.

TEST METHOD

Tests were performed using the Andersen impactor to determine particle size distributions and to obtain samples in various particle size fractions suitable for elemental analysis by x-ray fluorescence (XRF).

To determine particle size distributions the impactor was run with eight stages plus a glass fiber backup filter. To

obtain samples for elemental analysis, the impactor was assembled with a zeffluor back-up filter located at various stages in the impactor. This arrangement provided samples consisting of particles smaller than the cut-point of the stage preceding the zeffluor filter. Table D-2 summarizes the samples obtained for XRF analysis.

TABLE D-2. PARTICLE SIZE DISTRIBUTION SAMPLES FOR XRF ANALYSIS

Sample	Particle size range, microns ^a
Stage 2	<10
Stage 4	<4.8
Stage 6	<1.6
Stage 8	<0.65

^a Particle size cut offs will vary with flowrate through the impactor.

For each test site a set of filters were run with a 47 mm glass fiber filter in a 47 mm filter holder proceeding the Andersen impactor containing eight filter stages plus a glass fiber backup filter. The purpose of the 47 mm filter was to filter out all the particulate thus allowing only stack gases to contact the substrates and backup filter. These tests runs were used as blanks to determine if the flue gas reacted with the substrates and as a check on the sample recovery procedure.

Sampling times were varied to allow for uniform loading on the backup filter, and to prevent loadings of greater than 10 mg on any one stage. The flow rate was maintained at a constant rate throughout the sampling period while obtaining the sample isokinetically.

SAMPLER PREPARATION AND ASSEMBLY OF THE IMPACTOR

Impactor

The plate assembly was begun by placing the inconel spacer in the holder. Next, the "F" stage was inserted. A preweighed backup filter was placed on stage "F" and then another inconel spacer. This was followed by plate No. 8 which is oriented with the plate index groove. A preweighed glass fiber collection filter disc was placed on plate No. 8 so that the air flow through the orifices would not be disturbed. The spacer and crossbar were carefully placed on the collection disc so that no misalignment occurs. This was followed by plate No. 7, collection disc, spacer, crossbar, and so on. The stacking process was completed making certain that the index grooves on plates 1 to 8 and the index pin on plate No. 0 were aligned. All plates were handled by their edges only.

SAMPLING PROCEDURE

After selecting a sampling site, the stack pressure, temperature, and moisture were measured according to procedures described in the Federal Register.^{*} This data was obtained from the EPA Method 5 tests conducted simultaneously. The sample probes were positioned at a point of average velocity in the duct or stack but not closer than 1 meter to the wall. With the probe still out of the stack, the train was assembled as shown in Figure D-4.

^{*} Federal Register, Vol. 42, No. 160, August 18, 1977.

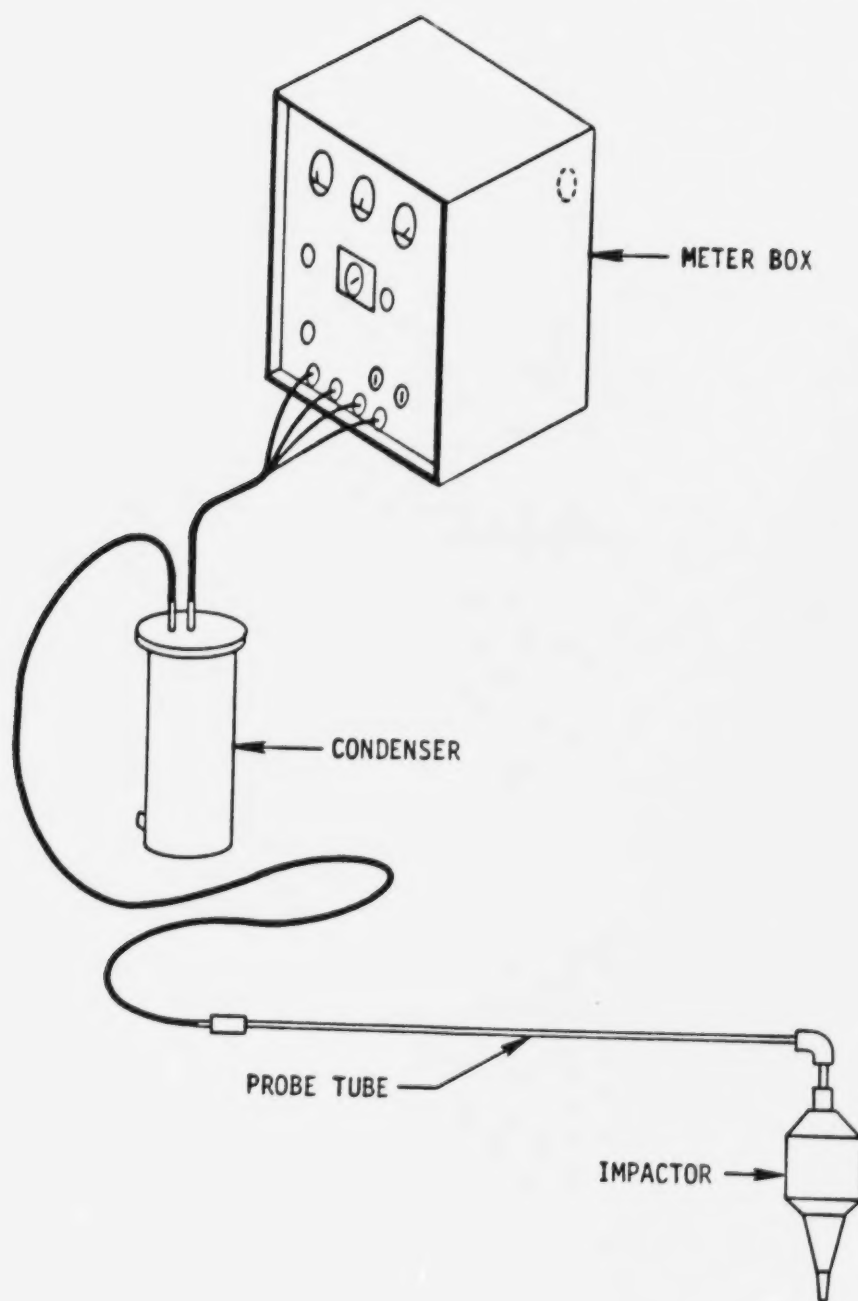


Figure D-4. Particle size distribution sampling train.

The sampling train was leak-checked at the sampling site prior to each test run by plugging the inlet to the nozzle and pulling 380 mm Hg vacuum. Once the desired vacuum was reached, the leakage was measured at the dry gas meter for 1 minute. If the leak rate was less than 0.6 lpm the tests were run. The pitot tube and lines were leak checked at the test site prior to each test run and at the conclusion of each test run. The check was made by blowing into the impact opening of the pitot tube until 7.6 or more cm of water were recorded on the manometer and then capping the impact opening and holding it for 15 seconds to assure it was leak free. The static pressure side of the pitot tube was leak checked using the same procedure, except that suction was used to obtain the 7.6 cm H₂O manometer reading.

During sampling, stack gas and sampling train data were recorded at intervals depending on the length of the run and when significant changes in stack flow conditions occurred. Isokinetic sampling rates were set and the constant sampling rate maintained throughout the sampling period. All sampling data was recorded on the Emission Testing Field Data Sheet.

SAMPLE RECOVERY PROCEDURE

Following the completion of the test run the impactor was removed from the probe and was moved carefully to the designated cleanup area, always keeping the impactor upright. Each filter was removed from its holder and carefully placed in its respective container. Particulate directly in front of and behind the filter was also brushed into the same container and then labeled,

and sealed. Loose particulate and acetone washings from all sample-exposed surfaces prior to the first collection stage were placed in a polyethylene bottle, sealed, and labeled.

ANALYTICAL PROCEDURE

Each glass fiber collection media and any loose particulate matter from its sample container were placed into a tared glass weighing dish, desiccated for 24 hours to a constant weight, and weighed to the nearest 0.1 mg. The acetone washings were transferred to a tared beaker, evaporated to dryness at room temperature and pressure, desiccated to a constant weight, and weighed to the nearest 0.1 mg. The term "constant weight" means a difference of no more than 0.5 mg or 1 percent of total weight less tare weight, whichever is greater between 2 consecutive readings, with no less than 6 hours of desiccation between weighings.

The zefluor substrates were sent to NEA Laboratories for elemental analysis by XRF.

CONTINUOUS EMISSION MONITORING SYSTEM

The continuous emission monitoring system (CEMS) was utilized to continuously extract flue gas from the process and determine concentrations for O_2 , CO_2 , SO_2 , NO_2 , and NO_x .

The accuracy of the data provided by the CEM system was dependent upon the gaseous stream analyzed as well as the correct operation of the individual components of the system. This section describes the CEM system and the techniques which were employed to ensure that a representative sample was extracted, analyzed and reported with a high degree of accuracy. The extractive monitors used in the study for O_2 , CO_2 , SO_2 , NO_2 , and NO_x are listed below.

<u>Gaseous Species</u>	<u>Principle of Operation</u>	<u>Vendor and Model No.</u>
NO_x , NO_2	Chemiluminescence	TECO 10-A
SO_2	Pulse fluorescence	TECO 40
O_2	Electro-Chemical Transducer	Theta Sensors Model 7211-1250
CO_2	Non-dispersive infrared Absorption	Infrared Industries Model 703-352

SAMPLING PROCEDURE

The following are the five general functions that were performed during the testing period to assure representative data by the CEM system.

1. Extract a representative sample from the stack.
2. Condition the sample for the monitors by filtering out the particulate and removing moisture to provide a clean, dry sample gas stream.

3. Transport the sample from the sampling port to the instruments without loss of sample integrity.
4. Provide for the introduction of calibration gases without disrupting sample flow.
5. Insure that the monitors will be sampling at a constant pressure, slightly above ambient.

SAMPLING METHOD

The CEM sample was continuously drawn through a glass-lined probe. A sintered steel cylinder on the probe acted as a coarse filter and a fine filter was placed just before the dryer. Both the probe and the fine filter were heated, and the intervening line was insulated to prevent condensation and possible loss of sample. A blow back system was used to periodically clean the coarse filter, and the fine filter was inspected daily and replaced as necessary. The dryer was a Perma Pure Model PD 1000-24PS, located as near as possible to the sample port. Plant compressed air and a permeation tube type dryer provided an uninterrupted stream of dry air. Only Teflon sample lines were used, and the exposed line was covered by a flexible sheath to prevent damage.

A one horsepower diaphragm pump drew the sample through the sampling interface and delivered it in excess to a glass manifold. The oversize pump guaranteed rapid system response to changes in stack conditions. Each monitor drew its sample from the manifold and the excess was vented. By restricting the flow at the vent, a slight positive pressure (2.5 - 7.5 cm H₂O) was maintained within the manifold. If the pressure drop across the sampling interface changed during sampling, a minor adjustment at the vent maintained the manifold pressure.

A second manifold was used for the introduction of calibration gases. This calibration manifold pressure was regulated to match the sample manifold and thus eliminate any pressure bias. Each monitor's sample line had a selection valve that permitted it to draw from either manifold. Thus any monitor could be taken off line, calibrated and returned to operation without interrupting the sample flow.

The monitors were subjected to a multi-point calibration at the start of the sampling period. The operator performed a zero and span check daily. Any values that exceed ± 5 percent of the expected reading would result in readjustment of the monitor. A second multi-point calibration was performed at the end of the sampling day at each location to insure that no deterioration of monitor response had occurred.

Quality assurance procedures for continuous monitors are designed to insure:

- ° Sample integrity,
- ° Accurate monitor response, and
- ° Precise and complete data capture.

The sample integrity was demonstrated first by leak checking the sampling interface from probe to distribution manifold. The absolute leak rate could not exceed 0.0005 m^3 per minute. Next, a known concentration of SO_2 was introduced at the probe. The analyzer response to this gas was recorded for at least one sampling cycle. The same gas was introduced directly into the analyzer and compared with the response of the sample line integrity tests. The two values had to agree to within ± 5 percent.

Assessment of the accuracy of each individual analyzer was accomplished by introducing known concentrations of the appropriate gas directly to each analyzer.

Field data was continuously recorded by HEATH/SCHLUMBERGER Model SR-204 strip chart recorders. The field operator validated the chart with date and time during the daily calibrations. Calibration values as well as comments and observations were recorded in the operator's log book for future reference.

Strip charts were reduced into a computer compatible form using a Thermographics I.D. digitizer. The digitizer operates on-line to a time shared computer. Individual data points were chosen at not more than fifteen minute intervals and averaged on a per hour basis, converted in appropriate units and stored on magnetic disc for subsequent analysis.